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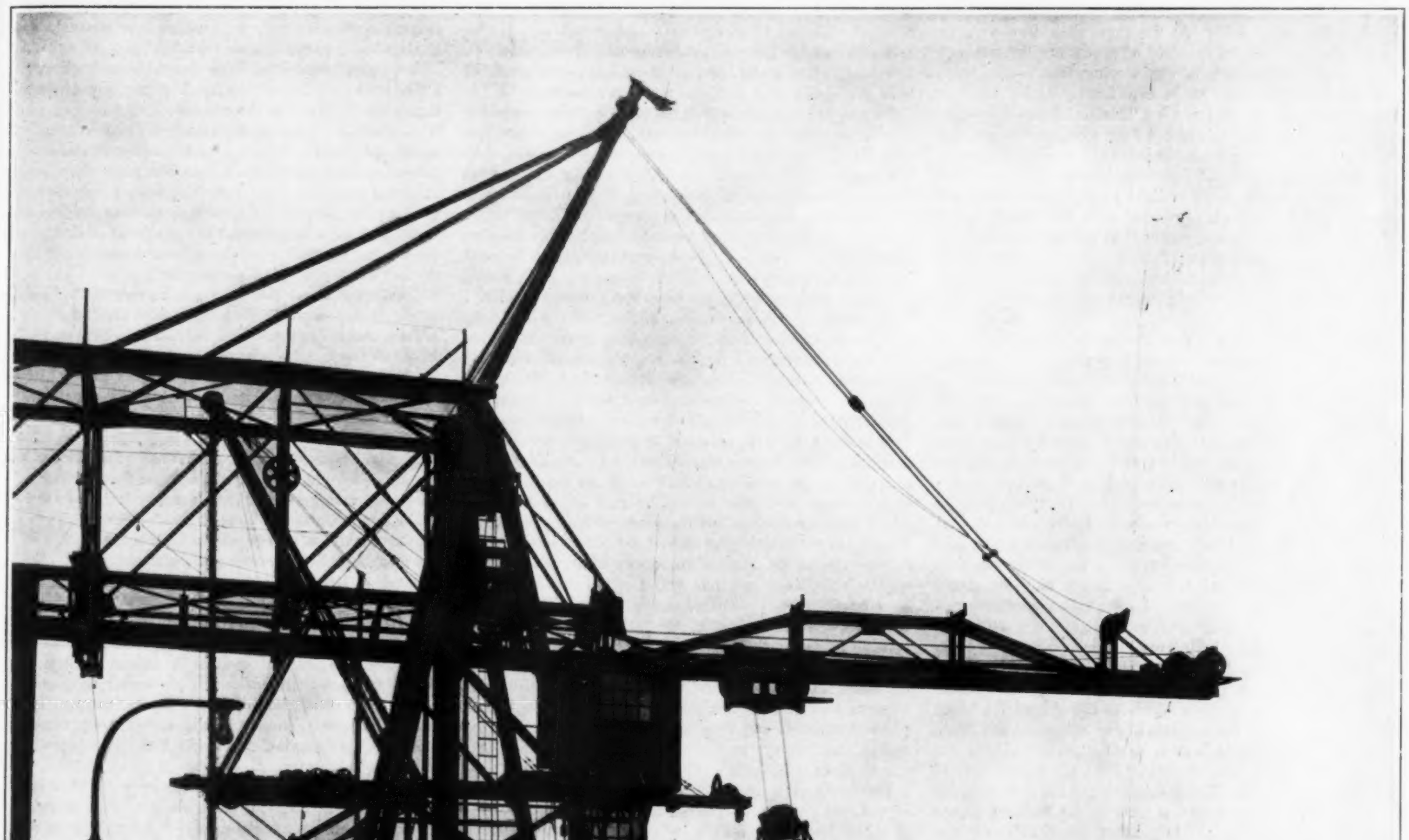


Apparatus for hoisting coal out of barges. The bucket is being hoisted and traversed at the same time.

THE FUEL SUPPLY OF A BIG POWER PLANT.—[See page 200.]

Light and Illumination*

A Survey of the History, Principals and Practice of Lighting

By Dr. Charles P. Steinmetz

ILLUMINATING engineering, that is, the art of producing light, is relatively one of the most encouraging branches of engineering, as it has in the last ten or fifteen years shown a wonderful progress in increasing the efficiency of light production many fold. At the same time, however, we may also say that in the field of producing light is met a discouraging branch of engineering, because in spite of the great progress made in economy of lighting, as illustrated, say, in the gas filled "Mazda" lamp of to-day, the efficiency is still only about 4 per cent, and 96 per cent of the energy consumed in the lamp is wasted. Although the efficiency is still low, nevertheless the advance from the days when efficiency of light production measured a fraction of 1 per cent, compared with that made in the last ten or fifteen years, means that we can hope for still greater improvement in the future. A wide field for such improvement remains, and instead of producing two candle power per watt, possibly twenty or more candle power may eventually be obtained.

It should be realized that the artificial production of light for illuminating purposes is comparatively recent, much more recent than is generally understood. I remember, for instance, my grandmother telling me that when she was young, resinous pine sticks were their only means for lighting; that was not so very long ago, and not in the wilderness, but in a civilized country. In my time vegetable oils were also used to illuminate, and I remember the first kerosene lamps, and that they had the reputation of being dangerously explosive and required careful handling. Gas was the street illuminant.

Then came the electric lamp. I remember the first incandescent lamp tried in my native city for street lighting, early in the '80s. I do not know whether it was a 50 volt or a 100 volt lamp. It was a small affair, giving a comparatively dull reddish yellow light not especially attractive. The first arc lamp there, however, was very different. Its exhibition was one of the startling features; the whole city, about the size of Washington, came to see the remarkable illuminant. All those things—incandescent lamps, arc lamps, even kerosene lamps, all our illuminants—are still within the memory of living generations. The whole field of lighting is really so new that only a very few generations back there was practically no artificial illumination applicable for general use.

In view of the progress of the art, within two generations, turning night into day, as it were, for useful work, we can imagine what future generations may accomplish, when we consider that there is still such a vast field for further improvements in efficiency.

Artificial light has always been produced by heat, first, by the heat of combustion, by burning pine sticks, vegetable oil, coal-oil, kerosene, gas, etc.; and, second, when the electric light came, in the same general way by heating the incandescent filament or the tip of the arc lamp carbon to a high temperature by means of the electrical energy put into it. Heat is produced in all these methods of lighting, and a small part of the heat comes out as light. The light is practically a by-product of the heat generated.

The first real advance beyond this way of obtaining light was made by Auer von Welsbach, who originated, in the Welsbach lamp, a method of lighting not dependent directly and wholly upon heat, but giving an illumination many times greater than any merely incandescent body would give at the same temperature. That was the first step toward a different method of producing light, a method that holds out a promise of possibility of efficiency greater than in producing light through temperature, that is, solely by heat.

To understand the subject better, let us first consider what light is. If a spring is slowly and regularly vibrated away from a contacting stop, we hear the stroke of each individual vibration. By moving it faster and faster until the frequency or rate of vibration is about thirty per second, the ear will no longer distinguish the individual vibrations; they would run together and blend into a continuous note, the deep bass C. If the spring is moved still faster, we would continue to hear a continuous note, of a higher pitch, however, corresponding to the particular rate of vibration.

This result can readily be accomplished by means of a star wheel arranged to rotate at any desired speed up to a very high rate, the teeth of which strike against a flat spring. For instance, if the speed be such as to obtain 250 vibrations per second, they are heard as a note in the middle C; and if the speed goes on increasing, we successively distinguish the notes D, E, F, G, A, B, and finally, at 500 vibrations, the next higher C of the musical scale, or C in the next higher octave. If the rate of vibration be decreased from 250, from middle C, down to half as many, or 125 vibrations per second, we hear the bass C, the C of the next lower octave.

So you see there is a definite scale for the frequency of vibration embraced in the octave, which, however, was originated long before people knew musical notes were the result of vibrations. And a system for the various frequencies of sound vibration has been established in the musical scale in which the octave is the unit. The octave changes from two to one; every time the frequency of vibration is doubled the same note of the next higher octave is produced; if the frequency is decreased to half, the same note of the next lower octave results.

But there is a limit to the ability of the ear to take cognizance of vibrations. Going from low to high and still higher vibrations the ear hears them progressively as musical notes of higher and higher pitch, finally becoming a screechy noise, no longer musical, when the rate reaches thousands of vibrations per second, and eventually a limit is attained generally between 6,000 and 8,000 vibrations, when the ear ceases to hear them, although sound waves are still being set up in the air and impinge upon the ear. The rate of vibration at which hearing stops is not the same with everyone; different persons hear higher up or lower down in the scale; but in general the range of frequency of vibration which can be heard as continuous sound or note is from about 30 vibrations per second, the deepest bass, up to 6,000 to 8,000, the highest pitch, embracing, say, six to eight or nine octaves.

Now suppose we go still higher in frequency, not in thousands, but in tens and hundreds of thousands, and even up to hundreds of millions of millions of vibrations per second. We can then again perceive them with our senses, not, however, with the ear as sound, but with the eye as sight.

Naturally vibrations at the rate of hundreds of millions of millions per second cannot be produced by any mechanical device, as the star wheel before mentioned; no body can be moved quickly enough to accomplish it. Moreover, the air cannot be utilized to transmit such rapid waves, because air, however thin it may appear to us, is altogether too dense and heavy a body to move so rapidly. Such extremely rapid vibrations have to be transmitted by a medium infinitely thinner and lighter than air, the universal ether, which is supposed to pervade all space and all matter, and transmits these very high frequency waves, some of which we can see as light.

When the rate of vibration of this ether is about four hundred millions of millions per second, the eye begins to see it as dark reddish light. At progressively increasing frequency we see it successively as orange, yellow, green, blue and violet light, until the rate reaches seven hundred millions of millions, when its effect upon the eye ceases and darkness ensues. There is, however, a frequency of vibration of the ether far beyond this, hundreds of times faster than the frequency of light. What we know as X-rays are perhaps the ultimate result of exceedingly rapid vibrations, amounting to many thousands of millions of millions per second.

We have seen that there is a range of vibration up to 8,000 per second perceptible to the ear, the air transmitting these comparatively slow vibrations as sound. Then there is another range of vibrations up in the hundreds of millions of millions transmitted by the ether, which the eye perceives as light. The range of frequency of sound waves is very wide, embracing about eight or nine octaves; but the range to which the eye is sensitive is only from about four hundred millions of millions to seven hundred millions of millions, relatively less than one octave. That is, the fastest vibrations which the eye can see are less than twice the slowest ones. Therefore, as regards the range of frequency of vibration the eye is much less sensitive than the ear; the eye perceives less than one octave, while the ear is sensitive to over eight octaves.

Now let us consider ways of producing sound waves. When one body is hit by another, say, by striking the table with a hammer, we hear a sound. Energy is expended by the blow and produces a mixture of vibrations of many different frequencies with no fundamentally predominating and controlling frequency, which are communicated to the air; the different frequencies result in a mixture of corresponding notes that are discordant or disagreeable to the musical sense, and thus we call such a sound a noise. Other noises, because produced by other different mixtures of vibrations of many frequencies, result from dragging a stone over a rough surface, permitting air under pressure to escape from a nozzle, swishing a whip through the air, etc.

Suppose instead of striking the table with a hammer, I strike a stretched steel wire, for instance, one of the wires in a piano. What is the result? The wire can vibrate as a whole at only one definite fundamental frequency, which determines the pitch of the note produced. It is true that superposed upon this vibration there may be others of a greater frequency, but, when present, they are so secondary to the fundamental wave as only to affect its shape in a minor degree, to the extent of determining the timbre or quality of the note and not its pitch, and do not cause a musically discordant result, that is, the vibration of the wires does not merely make a noise. It is, then, not able to vibrate like the table with a heterogeneous mixture of discordant vibrations of all kinds of frequencies with no controlling frequency, producing only a noise; the wire vibrates at a particular frequency, and the resulting sound will be a note, which, of course, is a noise in the most general sense, but not in the musical sense.

If, for another illustration, instead of making a noise by dragging a stone over a rough surface, I drag a bow across a violin string, the energy communicated will make the string move, but being able, like the piano wire, to move only at one particular rate of vibration it will produce a definite note, the particular note obtained depending upon the length of the string and tension upon it.

Again, take the case of an air blast escaping from a nozzle with a hissing noise. If I properly place a tin tube over the nozzle, the air in the tube will vibrate, but, like the piano wire, at some particular frequency depending upon the length of the pipe; thus the air blast can no longer cause an adventitious mixture of vibrations, but only that particular one which the pipe permits, and we get a definite note.

So you see we can create a noise by any sort of impact, but to get a definite note, that is, a noise produced by a definite frequency, the body which is set in motion must be so shaped that it can move only at one definite fundamental rate, like the violin string or the stretched piano wire or the air column in the pipe.

The art of creating and making musical instruments has always been to shape the material so as to get waves of vibration of definite stable frequencies and shape, the shape giving the difference in quality, color, or timbre of the notes of the different musical instruments. There must also be a rational method of supplying energy for producing such vibrations, by a felted hammer, as in the piano, or a bow, as with the violin, otherwise only a jarring noise is likely to result.

Analogous methods can be applied to obtain vibrations of the ether millions of millions times faster than sound waves, and which the ear cannot hear but the eye can perceive. If we put energy into a body by heating it, the body will send out ether vibrations at this higher rate. The collective vibrations thus obtained, translated into the language of sound, would be a noise, a mixture of waves of all kinds of vibrations with no particular fundamental frequency. If we heat the body to incandescence the same result is obtained. Now some of the waves, those which happen to be in the three quarter octave, will be visible to the eye; while others in this ether noise, this mixture of vibrations, may be too fast or too slow to be seen.

Let us see how we can get some definite rate of vibration, some definite frequency of light. To get a definite frequency of sound you have seen that the vibrating body, the violin string, the piano wire, or the organ pipe, must be properly proportioned. For example, to get with an organ pipe a vibration of, say, 250 per second, the pipe should be about four feet long, because a column of air that length is able to vibrate at the required rate. But if the vibration is to be at the rate of five hundred millions of millions of cycles per second, which would produce a greenish-yellow light, naturally the body to be moved at that rate must be extremely small.

Now the smallest body which is available is the chemical atom. In a piano, when a particular note is to be sounded, the key corresponding to the wire having the correct length and tension is struck. But we cannot strike each individual atom of the steel wire separately. It is much more difficult to get a single atom into vibration by putting energy into it than to get a piano wire,

*Presented at a joint meeting, Electrical Section, Western Society of Engineers, and Chicago Section, American Institute of Electrical Engineers, and reproduced from the *Journal of the Western Society of Engineers*.

violin string or a column of air vibrating, because we cannot act upon each vibrating atom directly but only on a big mass of them.

Atoms can, however, individually be set in vibration by various means. If an electric current is sent through a gas or vapor under low pressure in a vacuum tube, the individual atoms are set in vibration, and move with their own definite frequency, just as do the violin string or the piano wire, and give out, not an atomic noise, so to speak, but atomic notes of definite frequency. But while the violin string gives one frequency only, one note to the single string, we know now that the so-called chemical atom is not a simple thing, but has a very composite structure, and that it does not give a single note, but quite a number of different notes, corresponding in a measure to the sound produced by simultaneously striking a number of piano chords.

The chemical atom, therefore, gives a mixture of vibrations, not, however, as we get in noise, a mixture of all kinds of heterogeneous vibrations, but a definite number of separate definitely related vibrations, a so-called spectrum, representing the vibrations that the different components of the atoms, whatever they may be, are capable of producing. There may be a very great number of different vibrations, but with some materials we find in the visible three-quarter octave six different notes or colors, six different prominent vibrations constituting a spectrum of light, besides a number of lesser prominence and many more outside the visible range. These atomic vibrations are very complex, and the method which is very successful in producing definite simple vibrations of sound waves at low frequency, absolutely fails when we come to the high frequency of light. The best we can do with the atoms of gas or vapor is to get a definite number of distinct and related vibrations.

We can produce a noise, or all kinds of vibrations, at the high frequency of light, for instance, by heating, just as well as it can be done at the low frequency of sound by impact. And atom-noise is really what is wanted for lighting. A definite frequency is undesirable; for example, a light which had only one definite frequency, say, the frequency of five hundred millions of millions, would be greenish-yellow, and would show everything of one color. Therefore, at least for general lighting, a mixture of frequencies is needed—what in sound we call a noise.

In the range of sound for many purposes—for signaling, drawing attention, etc.—a noise is generally just as good as a note. What we are after is volume of sound, regardless of whether by a noise or a single note, but in lighting what is wanted is really a noise. In sound waves the range generally perceptible is eight octaves; practically any mixture of frequencies in making a noise will usefully fall in the audible range, and very little will be wasted. But in a mixture of frequencies of hundreds of millions of millions of cycles of light waves the visible part is only three quarters of an octave, and in such a mixture a considerable part of the vibrations is sure to fall outside the visible range, and become wasted as light. Thus the difficult problem of producing useful light is not only to produce all kinds of frequencies of vibration, but to produce as large a part of them as possible within the three-quarter octave that can be seen.

A most convenient method of producing frequencies of millions of millions of cycles is by heat, by raising the temperature of the body that is to radiate the vibrations. A steam heated radiator will send out vibrations at the rate of many millions of millions of cycles, but they will be just a little too slow to come within the visible three-quarter octave and are thus not perceptible to the eye.

Most of the vibrations from aluminium at the melting temperature probably 99.75 per cent, are too slow to be visible, but a very small percentage have a high enough rate to be just within the visible range, where the eye perceives them as red, orange and yellow, with possibly a trace of green. The general result is a dull red-orange color.

At a higher temperature higher frequency radiations are obtained. At the temperature of melting iron more than 99 per cent of the vibrations are too slow to be seen; most of them appear in the lower end of the three-quarter octave, as red, orange and yellow, with some green, a few blue and still fewer violet radiations, the color mixture appearing nearly white. In the visible three-quarter octave the slowest vibrations appear red and the fastest are violet, and from the fastest to the slowest throughout the visible range the colors are successively red, orange, yellow, green, blue and violet, just as we have the octave of sound waves divided into notes, C, D, E, F, G, A, B, and the next C. The next C has no equivalent in light, that is, in passing over the visible spectrum from red to violet, red is not repeated again beyond the violet; the spectrum of vibrations continues on, however, beyond the violet into an invisible region known as the ultraviolet.

At a still higher temperature, for instance, the temperature of melting tungsten, the percentage of frequencies of vibration that come within the three-quarter octave increases to 5 or 6 per cent. We get red, orange, yellow, considerable green and blue and some violet. The considerable increase in the number of higher frequencies in the blue and violet parts of the three-quarter octave give a mixture which produces almost a white light, much whiter than in the case of melting iron.

If the temperature is raised still higher, say, to about 5,000 deg. Cent., 9,000 deg. Fahr., about 10 or 12 per cent of the total frequencies will fall within the visible three-quarter octave. The highest efficiency of light production by heat would be at about 5,000 deg. Cent., about the temperature of the sun.

The problem of producing light from heat, by combustion or by an electric current, therefore, involves raising the light-giving body to as high a temperature as possible, because the higher the temperature the greater is the percentage of the total vibrations emanated that fall within the visible range. But even at the very best, if it were possible to make use of a temperature of 5,000 deg. Cent., we could not get more than 10 or 12 per cent of the vibrations as light. Unfortunately tungsten evaporates at between 3,000 and 4,000 deg. Cent., and other available substances vaporize at still lower temperatures; thus we are prevented in practice from attaining the maximum efficiency possible by radiation due to temperature.

Nevertheless, all the advance in illuminating engineering has been made by utilizing higher and higher temperatures. In the beginning, light was obtained through the temperatures obtained by combustion, ranging from lower to higher temperatures according to the combustible used, as flaming pine sticks, vegetable oil, whale oil, mineral oil, kerosene, etc., with an upper possible limit of about 2,000 deg. Cent., determined by loss of chemical affinity of oxygen for other elements at still higher temperatures. At the temperatures of combustion, red, yellow, and at the highest limit a whiter flame was produced, but all of them of low percentages of efficiency for obvious reasons heretofore given.

Then we came to the electric light. Although higher temperatures than 2,000 deg. Cent. cannot be reached by combustion, we can go higher by means of the electric current. Attempts at producing light by the electric current were made by heating wire conductors to a high temperature, and the first attempt at an incandescent lamp was with a platinum wire; but platinum melts at about 1,760 deg. Cent., therefore the efficiency of light production by this means is very low. Then Edison discovered that a wire of carbon—a carbon filament—could be used in place of platinum. Now carbon does not melt, or boil, until a temperature of about 4,000 deg. Cent. is reached. Consequently it should stand a very much higher temperature in an incandescent lamp than platinum. The old carbon filament lamps were run at about 1,800 deg. Cent., somewhat above the melting point of platinum, and thus with higher efficiency, and no danger of melting. About 45 watts of electrical energy were required per candle power.

The question arose: Why could not the carbon be operated at a higher temperature and thus at higher efficiency? If instead of running at a temperature of 1,800 degrees, requiring 45 watts per candle power of light produced, the carbon was raised to 2,500 degrees, the candle power would be doubled for the same watts. But the limitation there was, not that the filament melts or boils, but another limitation—evaporation. We know materials can evaporate below their boiling point, for example, that water at ordinary temperatures will evaporate within a few days, and that even ice and snow below the melting point gradually disappear. The carbon filament at 1,800 degrees, way below the melting and boiling point, also slowly evaporated, the carbon vapor being deposited on the lamp bulb. With continuous evaporation the filament got thinner, thereby the temperature went down and the light became less. The deposited carbon vapor also obstructed the light. If the filament were raised to 2,500 deg. Cent., the temperature would rapidly go down through excessive thinning of the filament by evaporation, and the deposited carbon on the globe would blacken it to such a degree that even the filament itself would only faintly be seen through the glass.

So we were limited as to the operating temperature of the carbon filament because it had to be kept way below the melting or boiling point, where the rate of evaporation does not unduly reduce the light production, and efficiency of that production, within a reasonable time, say, 500 hours or so. That was the limitation to the efficiency of the old carbon filament light.

The problem later was to make it possible to run carbon at higher temperature without undue evaporation, and thereby get higher efficiency. Carbon is a rather indefinite body; there is carbon and carbon, for instance, the carbon obtained from bamboo fiber, the carbon from silk strands and that from cellulose, and so on. The material obtained by carbonizing fiber evaporates rather rapidly, but carbon deposited from gasoline at high temperature is of another kind, which does not evaporate so easily, and thus can be run at higher temperatures. Therefore, if a shell of carbon from gasoline vapor is deposited upon the carbon filament of old produced from fiber, it can be run at higher temperature with equal falling off in light and blackening of globe, but we will get a higher efficiency, and this was done.

About ten or twelve years ago still another useful modification of carbon was found, represented in the so-called metalized carbon filament, which somewhat possesses the strength and resiliency of a hard-drawn metallic wire, and evaporates still less rapidly than the earlier carbon; therefore it can run at a higher temperature. This carbon is used in the filaments of the so-called "Gem" lamp, which can be operated at about twice the efficiency of the old carbon lamp with the same rate of evaporation, the same rate of blackening and the same light.

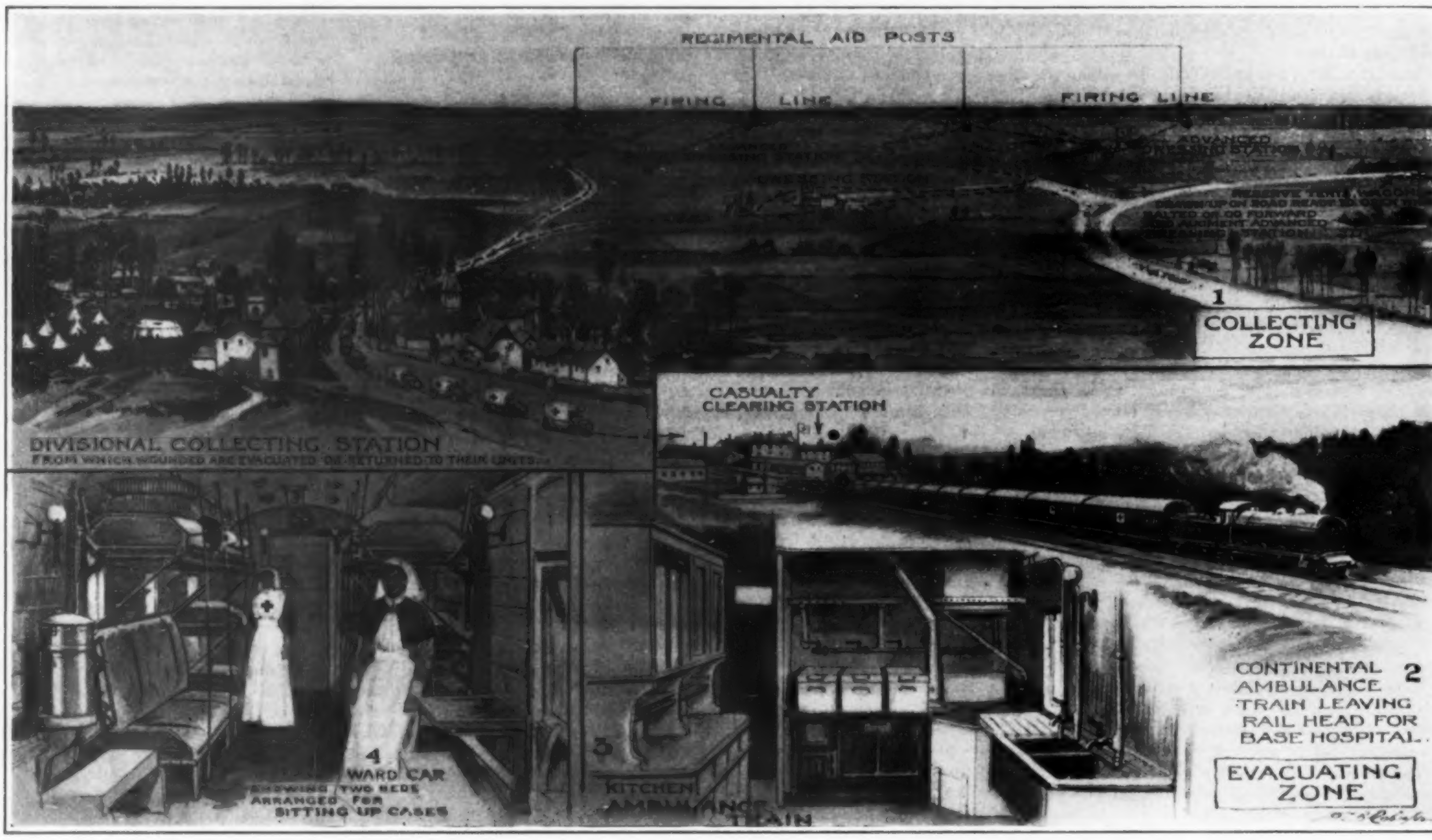
But even the temperature of the metalized carbon in the "Gem" lamp is still way below the temperature of boiling. We can produce light by running the temperature of carbon up to the limit, that is, to the boiling point, nearly 4,000 deg. Cent. We cannot do it with a filament, however, but must use the arc lamp, in which the current passes through hot vapor in the space between two slightly separated carbon rods and raises the tip of the positive carbon to the boiling point. The light emitted has the efficiency that would be obtained at about 4,000 degrees; all the evaporation takes place at the positive carbon, and probably 8 or 10 per cent of all the vibrations radiated are visible. Thus the arc lamp would give a very high efficiency were it not that an excessive amount of heat energy is conducted off by the carbon rods and carried away by the air. That is the main, and a serious loss.

The problem thus became one of finding something that can stand higher temperatures than carbon under all practical requirements. Tantalum, osmium and tungsten are all metals of extremely high melting points, but they have a characteristic advantage over carbon in that their rate of evaporation is much less at high temperatures. The carbon filament in the old incandescent lamp evaporated although it was operated at a temperature much below the boiling and melting point. Tungsten, on the other hand, can be run up high in the temperature scale nearly to the melting point with very little evaporation, so you see that the melting point, or boiling point, and the evaporating point have no necessarily fixed relation for different substances. Benzine and water, for example, boil at about the same temperature, but a plate full of benzine will evaporate long before a plate full of water. If carbon and tungsten are kept at the same high temperature, the carbon will evaporate rapidly, while evaporation from the tungsten will be very much slower. Therefore we can run tungsten at much higher temperature than carbon with the same evaporation, although really the tungsten would melt before the carbon. Carbon will stand higher temperature, but it then evaporates too rapidly.

(To be concluded.)

Experiments With Watches

The behavior of watches under varying conditions is an interesting study, and of considerable importance in connection with astronomical and physical investigations involving the element of time. Mr. J. J. Shaw, in the *Monthly Notes* of the Royal Astronomical Society, describes some observations of the behavior of a watch under various conditions, and especially in relation to the effects of suspension on the rate of a watch. The mode of suspension was found to have a serious effect, particularly if the watch itself is free to oscillate, and the rate appeared to be in close relationship to the synchronizing period and to the amplitude of swing. For testing purposes a light metal clip was contrived to hold the watch, fitted with two adjustable pivots, so that the period of the watch, acting as a pendulum, could be readily varied. A mirror was also fitted, and a reflected beam of light used to measure the arcual amplitude of the oscillations. The nearer the frequency of the watch approached that of the balance wheel, 150, the greater the gain. It was found impossible to get frequencies above 150 with the watch oscillating in the vertical plane, but by an adjustment of the pivot the rate could be tested in various angles and frequencies as high as 180 per minute were obtainable. The watch in the latter case was losing, and the nearer the balance wheel was brought into the plane of the oscillations, viz. vertical, the greater the change in rate; further, the more the frequency fell toward that of the balance wheel, the greater the loss. At 155 per minute the experiment becomes very critical, and the rate will suddenly change over from a maximum loss to a maximum gain, and *vice versa*, without perceptible change of frequency. The results obtained are in good accord with the theory of the double pendulum, and it is of importance to remember them if good time is to be kept. Examples from actual practice conclude the paper.



Courtesy the *Illustrated War News*

Diagram sketch showing route followed by the wounded, and a typical hospital train.

What is Done for the Wounded*

How They Are Collected at the Front and Transferred to the Permanent Hospitals

The extent and efficiency of the arrangements for the care of the wounded in the present war would lead to the belief that the experience of a long series of years and of wars had been brought to bear on the subject. As a matter of fact, however, no serious efforts to deal with this important branch of warfare were made until 1813, when an organized Medical Corps with horse ambulances was attached to the French army under Napoleon. The present Red Cross organization only had its beginning in the Italian war of 1859, and four years later, in 1863, a committee was formed for the purpose of framing a code of rules to be observed in war by civilized nations, with the object of reducing as far as possible the sufferings of the wounded in future campaigns.

The code of rules then formulated by this committee (known as the "Geneva Convention"), which was amplified at a second meeting in 1906, is now recognized. The Franco-Prussian War of 1870 and 1871 was the first conflict in which the code was put to practical use.

The organization required to collect the wounded at the firing-line and carry them to the home hospitals—without interfering with the transport of men, munitions, supplies, etc., in the opposite direction—is a most difficult task in the present war, when the best of roads and railways are quite inadequate to deal with the enormous amount of work enforced upon them by the tremendously severe nature of the conflict.

* From the *Illustrated War News.*

In order to facilitate the collection and treatment of the wounded, it is usual for the Medical Staff to arrange what are known as Regimental Aid Posts in the immediate vicinity of the firing-line, these being the headquarters of the surgeons and others of the staff whose business it is to render First Aid. Whenever such a course is possible, the wounded are carried to these Aid Posts by the stretcher-bearers.

At some little distance in the rear, Advanced Dressing Stations are provided, to which the stretcher-cases can be carried after the fight, or during the night, from the Regimental Aid Posts, by motor ambulances plying between them and the Divisional Field Hospital (Fig. 1—Collecting Station) some miles farther tot he rear. The Casualty Clearing Station, placed yet farther back and close to the railhead, receives the wounded from the Field Hospitals, and passes them on by ambulance trains to the Base Hospital, from which serious cases are taken home in ships specially fitted out with every appliance for this work.

In selecting the position for the chain of hospitals described above it is necessary that consideration should be given to the fact that the uninterrupted advance of troops, munitions, etc., is of the first importance. The route selected for the transport of the wounded must, therefore, keep clear of the advance, even though the route may be somewhat longer.

One type of British-built ambulance train (Figs. 2, 3 and 4) in use on the Continent consists of seven vehicles—four Ward Cars (Fig. 4), two Kitchen Cars (Fig.3), and a Pharmacy Coach. The cars are 57 feet long by 9 feet wide, and are painted khaki outside. They are enameled white inside. Electric light is used, with emergency candle-brackets, and steam-heating is supplied. Each Ward Car has thirty-six iron cots, arranged in three tiers, and so designed that the patient can be carried from the train to the hospital without being transferred to stretchers. The second tier of cots is arranged in such a manner as to fold down and form the back of a seat made by the bottom tier for use when sitting cases are being carried (Fig. 4).

The cars are fitted with double doors in the sides so that the patients may be carried in and out as directly as possible. The Pharmacy Car has an operating-room with a lead-lined floor, a dispensary, an office, and a linen store. Such a train can accommodate 144 stretcher cases, or a larger number of sitting cases. The coaches are provided with gangways to enable the attendants to pass through the whole length of the train. There are many British-built ambulance-trains running on the Continent, the make-up of which rests, of course, with the French authorities. A number of these have been presented by private individuals to the War Office. In England there are eighteen such trains in use, each made up of 9, 10, or 11 vehicles, with sleeping accommodation for the staff.

The Heart in Warfare

Examinations of the heart made in field hospitals and reported in the *Wochenschrift* (1915, No. 33) of the Vienna Clinics note that the results of the examinations of Austrian infantry are interesting. Of six soldiers sent in, diagnosed as having widely varying disorders, all showed on examination, made at the time of admission to the hospital, such a condition as to be suspected of having organic disease of the heart. On further study and examination this likelihood became less and less probable.

The disabled men usually arrived in the early afternoon, having come from three to four miles in ambulances.

Generally the condition of the heart next morning, that is, after an interval of 14 to 16 hours, was materially changed. Above all, no murmur was perceptible, and the cardiac dullness was almost normal. The condition improved in two or three days, and when the health otherwise permitted it the soldiers could return to their regiments, and generally did not come back for treatment during two months of observation at the same battle front.

The causes of these conditions were variously explained, ascribed partly to a prolonged influence of poisonous conditions in the field, partly to the presence of few well-trained soldiers and the unavoidable contagious illnesses, and partly to the excessive exertions and deprivations.

The chief cause of these heart failures, however, is in the psychical effect of the war. The patients did not have to make any great physical exertions before the examination; on the contrary, they had been lying for days in the same spot in the trenches. Among the sick were soldiers who had been only a short time at the front and had not really been put to any physical strain. The formations were relieved every two or three days, and while in the trenches there was really no work. Moreover, they suffered no deprivations, for their shelter was no mean one, in heated earthworths which were abundantly supplied with straw and shavings.

The soldiers were amply provided with winter clothing and blankets and commissariat abundant and good. Improved conditions followed almost immediately upon the psychical rest. Many patients were brought to the hospital only after two or three days in the trench hospital, and showed these heart symptoms quite decidedly on admission, but they soon disappeared. Soldiers came with a diagnosis of organic disease of the heart, when, with us, where the soldiers believed themselves quite secure from the fire of the enemy, their condition improved very rapidly.—From *Der Wiener Klin. Wochenschrift.*

English Rifle Grenades*

The English troops in Flanders are using a new weapon, the rifle grenade, the idea of which was suggested to its inventor, Martin Hale, by the successful employment of hand grenades in the Russian-Japanese war.

The Hale rifle grenade (Fig. 1) is composed of a brass tube 1.5 inches in diameter which incloses a smaller tube. The space between the tubes contains

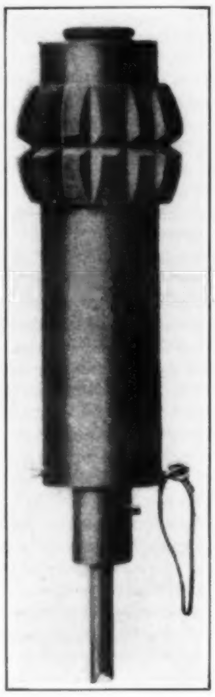


Fig. 1.—The Hale rifle grenade.

4 ounces of a very powerful explosive, which is exploded on impact by a cap containing fulminate of mercury, attached to the front end of the small tube. The cap is suitably protected against accidental explosion. The front end of the outer tube carries two heavy steel rings, nearly separated by deep grooves into 24 parts, which are torn asunder and hurled in all directions by the explosion. To the rear end of the small tube is screwed a steel rod which is inserted in the barrel of the rifle.

The grenade is thrown 150 yards by a powder charge of 30 graines, 300 yards by 45 grains. The grenade can also be thrown by hand. For this use the rod is unscrewed and the grenade is thrown by means of a cord attached to a peg provided for the purpose. The grenades can be used, furthermore, for destroying buildings, bridges, railways, etc. In such cases the rod is removed and the fulminate cap is replaced by a fuse.

A soldier can carry without inconvenience four grenades attached to the back of a belt (Fig. 2). If necessary he can carry a larger number, as the weight of the grenade is small.

Firing grenades from the trenches.

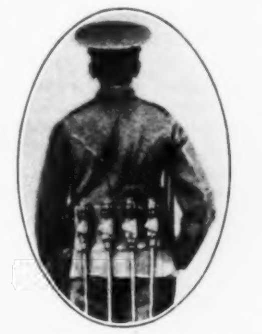


Fig. 2.—An English soldier carrying four rifle grenades in a special belt.

Prevention of Rust by Painting

Reference is made in the *Centralblatt* to some experiments that have been made by Liebreich and Spitzer on the effect of paint on the rusting of iron, especially as to a number of coats.

They polished four iron plates and painted them—the first with one coat, the second with two, the third with three, and the fourth with four. The plates were then exposed to steam for one day. The paint was dissolved off and the following distinct results noted:

The iron under the single coat was bright all over, that under two coats was partly rusted, that under three coats rusted still more, while the iron under the four coats was covered with rust. This experiment shows that several coats of paint do not protect as well as one coat.

The explanation of this is that subsequent coats of paint or varnish tend to dissolve part of the previous coat. This has the effect of loosening the previous coat and making it porous, the porosity increasing with the number of coats. Air and moisture penetrate the pores and the iron below is rusted.

Where rust is feared, the coat of paint or varnish is usually made too thick, and the application of a second and third coat naturally does no good. The proper procedure is to remove all old paint by using the sand blast, solvents, etc., and then give the clean iron surface a single coat of the paint or varnish.

* From *Die Umschau.*

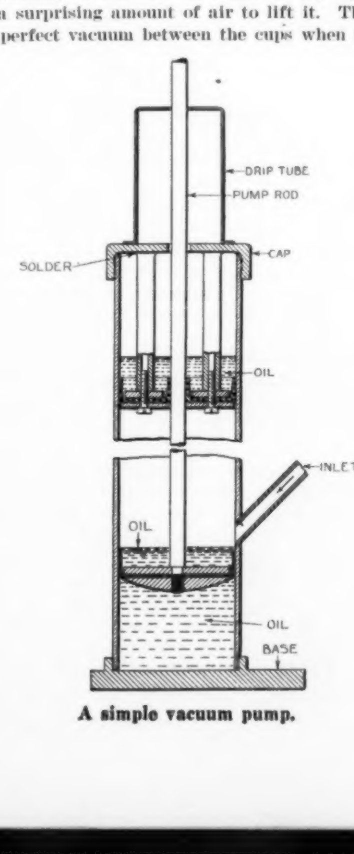
A Simple Vacuum Pump

By Charles E. Duryea

Often a good vacuum is required and no ready means at hand to produce it. In these days of cheap pumps for auto tires a good vacuum pump can be easily made. Select a pump with a screw cap and a long barrel which may be unscrewed from the base. Close the outlet in the base and solder an inlet tube in one side of the barrel about two inches above the bottom. This inlet tube should extend outward and upward at about 45 degrees so that any oil which may enter it will return to the barrel. The leather cup on the pump rod should be turned over so as to act on the pull stroke. Fit a similar cup two or three inches below the top, which may be supported from the top cap by two or more short rods soldered to the top and the metal parts which hold the cup. The cup leather for this cup should be stretched up in its center so as to form a packing around the pump rod. If a cup already with a hole through it is used a second layer of leather may be added to make this rod packing. On top the cap solder a tube about two inches long to catch any oil the pump rod may carry out with it. The pump rod fits loosely in the hole through the top so the air can get out alongside of it freely and any oil can run back easily. Screw the bottom on the barrel, pour some oil into it and insert the parts. Depress the piston cup as far as it will go. The oil should more than fill it. Raise it as far as it will go and the excess comes into the top cup, and partly above. There must be no hollows on the underside of either cup to hold an air bubble. If a little more certainty is desired at this point conical nuts can be used to grip the cups and they may extend to the barrel walls.

The down stroke now starts with no air between the cups and an oil seal to both cups. Little imperfections of the cups do not matter if the oil is fairly heavy, as for example gas engine cylinder (auto) oil. The space between the cups fills with air from below which meets some resistance forcing its way past the cup and oil until the cup passes below the inlet tube, when this resistance is away and the barrel has a vacuum equal to the vessel being exhausted. The piston cup sinks into the oil below, filling itself again to normal level, and begins to carry the air above it as soon as it passes the inlet opening. At the top it empties completely, forcing such oil as has leaked in from the top cup, up into it again.

Most air pumps fail when there is no longer enough air remaining to lift the valve and a very light valve takes a surprising amount of air to lift it. This pump has a perfect vacuum between the cups when this non-raising condition is reached, and as soon as the piston cup passes below the inlet this vacuum fills from the exhausted space with no resistance whatever. Possible air bubbles and a slight oil vapor seem to be the only dangers. If the last strokes are made slowly and with some interval between, the bubbles will float to the top and pass into the cup above with the excess oil. If oil vapor is feared boil the oil till all low test vapor passes off. The space above the top cup should be long enough to hold the oil in it without spilling when the pump lies flat. The oil-catching tube may have a flange inside its top end for the same purpose.



A simple vacuum pump.

Flow of Air Through Nozzles

Experiments undertaken to compare various forms of nozzles in respect of their effectiveness for the production of jets of air having as high a mean velocity as possible were discussed by Captain Thomas B. Morley in a paper before the Institution of Mechanical Engineers. An investigation into the nature of the impact produced by a jet upon a flat plate and its relationship to the reaction of the jet was also described.

Nozzles with different entrance curves and with divergent portions of different lengths and tapers were tested, together with orifices in flat plates. The velocity of the jet was determined from measurements of the impact of the jet upon a flat plate, and also from the reaction of the jet.

EFFICIENCY OF NOZZLES.

The principal conclusions from the experiments were: The highest discharge coefficient is obtained with a short convergent nozzle, the coefficient being 0.98. The addition to a nozzle of a divergent part after the throat slightly reduces the coefficient unless the taper is very gradual. The impact of the jet upon a flat plate varies as the distance of the plate from the nozzle alters, the maximum impact being attained at a distance of about 8 inches. The velocities calculated from the maximum impact are about 12 per cent higher than those calculated from the reaction. The best velocity results are obtained with short convergent nozzles, the efficiency of these being practically unity. The addition of a divergent part after the throat is in general a disadvantage, and in some cases may seriously reduce the efficiency. For pressure up to 50 pounds per square inch orifices are as efficient as the best nozzle form. For an orifice the discharge coefficient varies with pressure, increasing with higher pressures, though it is much less than that for a good nozzle.

The author remarked that, in view of the high efficiency with which the expansion of air in nozzles may be carried out, and the advantages in many circumstances of the turbine over the reciprocating motor, there appears to be a distinct field in which, where power is transmitted by compressed air, the reciprocating motor might with advantage be replaced by an air turbine.

IMPACT AND REACTIONS OF JETS.

After a discussion of the possible causes of the variation of the impact as the distance between the nozzle and the impact plate alters, the author showed that the expansion of the air is practically complete at the exit from even the shortest nozzles, and that the free jet is approximately parabolic in form. The experiments indicated the conclusion that when the flow from a nozzle begins, an "energy system" of circulating air is set up in the atmosphere round about the jet, which, when once established, absorbs very little momentum from the jet, but adds the full effect of its momentum to the force applied to the impact plate. For this reason the recorded impact is higher than the true momentum per second of the jet, and therefore higher than the reaction, since there is no evidence that the reaction does not correctly represent the true momentum per second. The author outlined a rough theory of the variation of the impact with distance from the nozzle, and recommended that for the experimental determination of jet velocities the reaction should be measured in preference to the impact.—*Engineering Supp., London Times.*

Application of Chemistry by the Municipality*

Some of the Many Places Where a Knowledge of Chemistry is Essential

By Hermann W. Mahr †

CHEMISTRY has for the last decade been a valuable aid in securing the health and well-being of the dweller in American cities. Its fields of activity have been the inspection of foods, the all-important duty of controlling the quality of the water supply and the disposal of sewage. Beyond this, science has only in rare instances been called upon for regular aid by the municipality.

In the meantime chemistry has been becoming an important factor in the industrial field. Chemists have improved processes and brought forth new products, many of which are finding wide use in civic housekeeping. The position now occupied by applied chemistry has led the far-seeing to herald the near future as the age of chemistry. With the advance in the industrial field have come additions to the knowledge and improvements in the methods of the science which now enable it to successfully attack special problems confronting our cities.

The chemists at present engaged in the all-important work of aiding in the conserving of the public health are often too well occupied with their duties to give time or attention to the technical problems which arise. Municipal engineers attempt to solve these questions, but are handicapped by a lack of knowledge of industrial chemistry and the ability to think chemically. These conditions give rise to opportunities for the chemist to aid the engineer and become his active co-worker. Members of the profession entering this work must necessarily be well acquainted with the processes of applied chemistry, and the methods of analysis and testing of industrial products, particularly the materials of engineering.

Our Federal Government has been a pioneer in this respect and its researches have redounded to its material advantage. It now has in its service well-informed experts in many branches of industrial chemistry. The results of their investigations have been published, and many of them are invaluable to the municipality. The latter should have in its service chemists able to apply the results of these Governmental and of other technical investigations to the problems of the city.

A large portion of the expenditure of the municipal corporation is for the purchase of supplies. The value of the chemical laboratory in connection with this work has long been recognized. Some of our railroads were the first organizations to avail themselves of scientific supervision and inspection in this connection. The Federal Government has followed their lead and carried on the work through the Contracts Laboratory and similar testing stations in the large departments.

The first duty of the chemist concerned with the purchase of supplies is the inspection of materials delivered. Study of the various commodities and the framing of requirements is second only to the work of testing. Many proprietary compounds, of supposedly secret composition, with alleged wonderful properties, are urged on purchasing officials. On being subjected to chemical analysis these materials often prove to be composed of cheap ingredients for which a price greatly in excess of their value is asked.

The fuel bill of the municipality is probably the largest item of its budget for supplies. Competitive bidding, in accordance with well-drawn specifications, has been universally adopted among large coal buyers as the best solution of the problem. In spite of its manifest advantages, city officials have hitherto been backward in putting a purchasing method of this nature into operation. The chemist can aid here greatly by studying the composition and heat value of the available coal supplies, drawing up requirements and testing shipments.

His labor in relation to fuel should, however, extend to overseeing its proper and economical use. The importance of the fuel question has, within recent years, assumed such proportions that chemists designated as fuel engineering chemists now make a specialty of the subject of fuel burning. A chemist, in municipal service, devoting himself to the wider application of chemistry, can make profitable studies of the methods of coal burning in schools and other public buildings. Wasteful grates may be found which require changes in the size of coal, and possibly expensive coals are burned where cheaper grades would adequately and economically furnish the required heat. Poor methods of stoking often allow opportunities for improvement with consequent saving.

Closely connected with the fuel question is that of obtaining proper boiler water. This part of municipal housekeeping is often entirely neglected, with a resulting increased consumption of fuel and decreased life of the heating or power apparatus. In some cases the man in charge is persuaded to buy a solution of sal soda and soda lye for a price many times in excess of its value. This mixture may or may not be adapted for use with the water in question. An examination of the water supply from the feed water standpoint will reveal the causes of trouble and enable the chemist to prescribe an inexpensive compound or the proper method of treatment.

There are many commodities purchased in large amounts whose composition is well enough known for them to be bought on specifications and subjected to test. One of the chief of these materials is soap, the cost of which is a considerable part of the amount expended for supplies. The Federal Government and railroads have long bought soap on well-drawn requirements.

Within recent years the fact that "there is paper and papers" has been recognized. Large concerns are now paying attention to the quality of this material. The paper experts of the German Government have made investigations and devised tests and methods of analysis for ascertaining the value of various papers. The uses of these methods have become known and are taken advantage of in the paper trade and by large users. Our municipalities are among the latter and can gain materially by scientifically scrutinizing paper supplies.

Rubber hose is an expensive necessity purchased in considerable amounts. On its quality and strength much depends. This has led insurance underwriters to require that hose for use in insured buildings be of the highest grade. Inspection of rubber requires it to be subjected to thorough chemical analysis and severe chemical tests. Cities should demand and make certain that hose for use by their fire departments and in public buildings is of the best quality.

Construction work of various kinds consumes a large portion of the civic bank credit. To obtain lasting structures and roads and prevent the use of inferior materials, the latter must be continually examined. Iron and steel should be subjected to chemical and microscopical analysis. Cements require chemical as well as physical tests. Results obtained by the chemist on a concrete containing one part cement to twelve of aggregate instead of one to six, will often furnish grounds for civil or criminal action against an unscrupulous contractor. The waterproofing of concrete has occupied the attention of the engineer and technologist within the last few years. The importance of the subject has resulted in the appearance of many worthless waterproofing compounds whose nature and value can be best revealed by chemical analysis.

Paints and protective coatings have been investigated to good effect by our American chemists, and their results have put this subject on a scientific basis. An understanding of these principles and knowledge of the properties of paints is necessary for the adequate protection of municipal buildings and structures.

Modern traffic conditions have been instrumental in bringing more of the products of applied chemistry into use by the city than any other influence. The ingenuity and experience of the oil and coal tar chemists have been drawn upon to solve the problems arising from the use of the automobile. Various forms of pavement with permanent bituminous binders have come into wider use. The manufacture of new asphalts from oils in order to supplement the natural deposits owes its impetus to the demand thus created. Treatment of coal tar for use in tar macadam and as a semi-permanent surface binder has occupied the attention of the chemical technologist for the same reason. The lighter tar and oil products have also been studied and experimented with in the effort to produce dust preventives. Treated wood block pavements are meeting with increased favor. Upon a knowledge of the properties of various treating media and thorough inspection and testing rests the success of these pavements and the comfort of those compelled to use them.

The city is called upon to apply the principles of preventive medicine on a large scale. Municipalities thus consume large amounts of antiseptics in their health departments. Disinfecting compounds flood the market. They, however, vary widely in ability to kill the various pathogenic organisms. The use of scientific tests for disinfecting value is not widespread in this country, but their introduction and use would result in a saving to the municipality with increased surety of the effect of treatments. Scientific inspection of disinfectants is a subject which also touches the household. It should be placed on the same plane as food inspection. Use of an inefficient antiseptic will often lead to more serious consequences than the consumption of a sophisticated food product.

Fire authorities have recently directed their energies toward the prevention of fires rather than their extinguishment. To make sufficient and effective rules governing the use and transportation of combustibles and enforce them requires the advice and service of members of the chemical profession. Within recent years the widespread establishment of garages has greatly increased sewer explosions. Chemical investigation is required to control this problem and place the blame at the proper source. The ultimate solution of the difficulty rests on chemists working in collaboration with the plumbing and sanitation experts of departments having authority over the erection of buildings.

Fireproofing and requirements in regard to it also occupy the attention of the latter departments. We owe our modern fire-resisting materials largely to the work of technologists in the chemistry of ceramics. The National Government has appreciated this fact, and now maintains a department of the Bureau of Standards for testing and research in ceramics.

A problem which has been given much thought and attention by municipal officers is the disposal of refuse, especially garbage. No satisfactory or altogether profitable method of disposal has been evolved. The treatment of this waste has not as yet been well studied by the chemist. The field of work, being comparatively unexplored, offers commensurate reward to members of the profession who shall bend their energies to the work. The most apparent method of increasing the value of garbage is that of rendering available the nitrogen of tankage, which is now mostly in forms of little value for fertilization.

Legal investigations have in many important instances been aided by the services of chemists. The opportunities for their work in this connection are more varied and numerous than have been realized. This leads to the belief that the future will see a chemist with his microscope and laboratory attached to many police departments. His work will be not only the present well-known toxicological investigation, but he will devise and apply delicate methods to the interpretation of clues which have in the past been closed books. The service rendered by that new branch of chemistry, metallography, is one instance of this. Boiler explosions have been difficult to trace to their origin, but microscopical examinations will often reveal faults in the heat treatment or structure of the metal which have caused disaster.

The foregoing outline suggests only a few of the possibilities for assistance that chemists may render our municipalities. An appreciation of the value of the science is necessary in the progressive civic official. More frequent attempts to throw the light of chemical research on problems will lead to satisfactory and even gratifying results. Surely the science of Liebig, Perkin and Bunsen can render increased aid to our American cities.

*Reprinted from the *Journal of Industrial and Engineering Chemistry*.

† Of the Standard Testing Laboratory of the Board of Estimate and Apportionment of the City of New York.

Chinese Weights and Measures

THE system of weights and measures in China is in an even more chaotic state than the currency and is characterized by the same lack of uniformity. The decimal system is used in theory but is not always adhered to in practice. The principal weights are 10 li = 1 fên (candareen), 10 fên = 1 ch'ien (mace), 10 ch'ien = 1 liang (tael), 16 liang = 1 chin (kin) or catty, 100 chin or catties = 1 tan or picul. In native trade the catty ranges from 12 to 42.5 ounces, and the number of catties per picul varies from 90 to 280. For purposes of foreign trade the customs authorities have fixed the liang, or tael, at $1\frac{1}{3}$ ounces, or 583.3 grains, avoirdupois, the catty at $1\frac{1}{3}$ pounds, and the picul at $133\frac{1}{3}$ pounds.

The measures of length are 10 fên = 1 ts'un (inch), 10 ts'un = 1 ch'ih (foot), 10 ch'ih = 1 chong (pu or kung), 180 chong = 1 li. The ch'ih, or foot, varies from 8.6 to 27.8 inches in different parts of the country. For customs purposes it is fixed at 14.1 inches. In measuring cloth the foot used in some parts of China is sometimes 11.1 inches and sometimes 13.85 to 14.05 inches.

The principal measure of area is the mow, which is regarded at Shanghai as equal to one sixth of an English acre (7,260 square feet), but which varies throughout China from 3,840 to 9,964 square feet, with one standard of 18,140 square feet.—*From Special Agents Series, No. 107, U. S. Department of Commerce.*

The Relation of Rodent Plague to Human Infection*

How Infection is Transmitted, and Measures for Prevention

By W. C. Rucker, M.D., Assistant Surgeon-General, United States Public Health Service

THE most essential factor in the control of plague during recent years has been the realization that it is essentially a rodent epizootic. It is true that the literature of plague contains reports of the disease in monkeys, dogs, cats, horses, asses, cattle, sheep, goats, swine, calves, chickens, pigeons, geese, camels, kangaroos, bats, frogs, geckoes, goldfish and carp, but many of these reports are not confirmed by convincing experimental evidence.

Hankin[1] noted an epizootic in monkeys in October, 1897, at Kankhal, and a second simian epizootic was observed at a little later date at Jawallapur. A third series of casts was observed at Gadar in the residency of Bombay in December, 1899. In the second and third simian epizootics the diagnosis was confirmed bacteriologically. Calmette and Salimbeni[2] and the German and Russian plague commissions demonstrated the susceptibility of the brown monkey and the gray monkey to plague. From the collected evidence it may be deduced that while monkeys have a great susceptibility to plague infection, they do not seem to play an important rôle in its propagation under natural conditions.

While there are a number of reports on the susceptibility of the dog to plague infection, a study of them does not warrant the belief that the dog is liable to the disease.

There are a large number of reports on epizootic plague among cats, yet these animals probably play a very unimportant part in the continuance and spread of the disease. Hunter[3] concludes that cats are susceptible to plague and that they suffer from an acute or chronic plague septicemia. He was of the opinion that they infected themselves by eating infected rats.

Horses are moderately susceptible to plague infection when pure cultures are injected into their blood streams in relatively large doses. A careful review of the literature does not disclose an instance in which they suffered from the disease in nature.

Schreyer,[4] K. Matsuo,[5] and Wu Lieu Teh[6] have reported that coolies working in a coal mine were attacked by pneumonic plague-infected donkeys with the disease. These are very extraordinary conditions and may be accounted as practically negligible in the course of an ordinary epidemic.

Under natural conditions plague has never been found in bovines. It is true that Simson[7] reported ingestion plague among calves, chickens, pigeons, dogs, geese, sheep and swine, but Bannerman and Kapadia,[8] the German commission,[9] and Hafkin and Lowson[10] have reversed his reports. It is, therefore, logical to conclude that these animals do not play a rôle in plague perpetuation or dissemination.

Since 1899, when Dchurkowski[11] described an infectious disease of camels closely resembling plague, there have been several reports of alleged outbreaks of plague in which the camel was the vehicle. The Astrakan commission decided that the camel was susceptible to plague and suggested that these animals might have been the means by which plague has been introduced into countries along the caravan routes. It is doubtful, however, if camels play any great part in the large problem of plague.

The report of the Board of Health of Sydney, 1902, contains a note by Thompson, in which he states that in the epidemic of that year seven kangaroos died from plague in the zoological garden at Sydney. This is an isolated instance and without bearing on the general problem.

With regard to bats, the reports are at variance. Gosio,[12] experimenting with the *Vesperugo noctula*, believed that he was able to infect them. On the contrary, Toyama[13] reported these animals as insusceptible.

It seems to be fairly clearly demonstrated that birds in general, and particularly birds which run on the ground, are not susceptible to plague.

The cold-blooded vertebrates, that is, reptiles and batrachians, have been experimented with by Nuttal,[14] Dwelll,[15] Furth,[16] and Fukahara,[17] and do not seem susceptible to plague, either by injection or ingestion.

Mention need not be made of the rôle of insects and *Ixodidae* in relation to plague, their part being the transmission of the infection from host to host rather than the function of keeping the disease alive within their own bodies.

The rôle of the rat in the pathogenesis of plague is classical and there is a preponderance of evidence which proves that bubonic plague in man depends entirely on the presence of the disease in rodents. It is true that in the pneumonic form of the disease infection occurs directly from man to man without the intermediation of any ectoparasite, but the great bulk of plague is not pneumonic, but bubonic, and it is the rodent species which keeps the disease alive and which carries it from country to country and into the home of man. Plague has been found in nature in the *Mus norvegicus*, the *Mus rattus*, the *Mus alexandrinus*, and the *Mus musculus*. The *Nesocia bandicota*, or bandicot rat; the *Arctomys bobac*, or tarbagan; the *Putorius furo*, or ferret; the *Herpestes griseus*, or mongoose, and the *Netotoma fuscipes*, or brush rat, have all been found susceptible to the disease. All of the spermophiles have proved infectible, as have also the *Cynomys Ludoviciana*, or prairie dog, and the *Putorius feotidus*, or skunk. The *Citellus grammurus*, or rock squirrel, and the *Citellus beecheyi*, or ground squirrel, have also proved infectible. The disease has been found in nature in brush rats, skunks and ground squirrels. The overwhelming fact in plague perpetuation and spread is that it is a rodent disease.

It is interesting to study the distribution of human plague cases in their relation to rodent plague cases. It is, of course, impossble to discover every case of rodent plague and on account of the migratory habits of rats it does not necessarily follow that the infection exists in large amounts at every place in which plague rats are taken. On the other hand, the impossibility of determining accurately the movements of human beings renders it difficult at times to discover the exact place at which infection was received. Not infrequently, however, plague rats are found in or near the building in which the human plague victim worked or lived, and the reverse is even more true, that human plague does not occur among people who work and live in rodent-free surroundings. Of the thirty cases of human plague which occurred in New Orleans in 1914, only five were unconnected with rodent plague foci, and in many of them the place at which the infection was received was accurately determined.

The foregoing is the basis of the measures for plague prevention and eradication. Since plague is a rodent disease, if man is isolated from rodents he will not under ordinary circumstances contract the disease, the key to prevention being the separation of man from rats.

It is manifestly impossible to kill all of the rats in a given community, much less in a whole country, or the entire world. If their migrations can be controlled, if they can be excluded from the places in which man lives and works, the maximum result has been accomplished. Wide migration or rats occurs largely by ships, a relatively very small number traveling overland by trains. The frequent periodic fumigation of ships, the breasting-off and rat-guarding of non-fumigated vessels, and the inspection of outgoing and incoming cargoes will, to a considerable degree, control wide rodent migration. The ratproofing of buildings used by man for any purpose whatsoever will keep rodents out of intimate association with man. For this purpose impervious materials, such as concrete, brick, stone, and tile, have their architectural application. During the presence of a plague epizootic the extermination of rats by traps, poisons, and separation from food supply so diminishes the density of the rodent population as to limit the spread of the disease from the sick to the well, and thus the disease automatically dies out for want of infectible material. This in effect is the dilution of the infectible material. At the same time the laboratory examination of captured rodents affords an accurate guide as to the centers of rodent infection and permits the application of intensive preventive methods so that the disease may be stamped out among rats before opportunity has occurred for it to be transmitted to man.

In the presence of an epidemic, every measure which will protect man should be taken. Among these is immunization against the disease after the method of Haffkine. This is of doubtful applicability in American cities. It could never be made mandatory, and those persons who volunteer for such inoculations do not form the class which is most liable to receive the infection. This method has not proved useful in large eradicative measures, it having been found more practicable to limit the operations to rodent extermination and the exclusion of this species from the home of man.

ABSTRACT OF DISCUSSION.

Dr. William C. Hassler, San Francisco: The paper gives us a very clear insight into the animals which are carriers of this disease. The point that I was particularly interested in was the matter of prophylaxis. I was the first one to receive a dose of Haffkine serum here in 1900. I was then acting chief sanitary inspector of the Health Department. We tried to impress its harmlessness on the Chinese population here whom we then had in quarantine. It was all right as long as they saw us getting the dose, but a few days later when we came to demonstrate the harmlessness of it, and our arms were swollen about the bigness of a goose egg, we had great difficulty in inducing them to submit to the measure. It would not work and we had to adopt other measures. Nevertheless, it is a safeguard which can be used and has its value under certain conditions.

Dr. W. C. Rucker: It may be of interest to this section to learn a little bit about the results of the campaign against plague in New Orleans. New Orleans is to-day 75 per cent rat-proof. The probabilities are that there will be 15 per cent of the city which cannot be rat-proof for several years. There therefore remains only 10 per cent to be done. This is being accomplished. Up to the present we have captured in the traps alone over 375,000 rodents. They are being taken at the rate of about 1,100 per day. Of these, 247 have been found infected, the last one having occurred on June 11th. We are now getting plague rats at the rate of one out of over 21,000. They uniformly come from buildings and premises which are not rat-proof. There were thirty human cases, of which nine patients died. The probabilities are that had it been possible to give all of those patients the serum treatment very early and in large doses, the mortality would have been very much lower. All of the rats were identified as to sex and species; and in this connection I desire to point out a very interesting gage on the value of your work. If you are carrying on a rodent extermination campaign, it is interesting to have a check by means of which you may know whether you are really killing rats. The trapping of mice in a campaign is entirely incidental. You do not aim to catch more mice; and in the beginning of the campaign it will be found that the number of the true rats will be very high, something like 91 per cent of the entire catch. If you will plot those on a chart you will find, if your work is successful, that there is a steady fall in the number of true rats, and that there is a steady rise in the number of mice, until you come to a point, as we did away along last December, where the mouse line has passed and far exceeds the rat line. In other words, you have been killing off, if your work is successful, the natural enemies of the mouse, and the mouse is therefore able to come out and get into your traps. We have in our exhibit at the exposition a very good chart showing this very simple point.

My paper, I feel, has been trite, but I think that it is a wise thing to tell the story over and over again, that so long as you have rats you are liable to have rodent infection, and that so long as you have rodent infection you are liable to have human infection and plague.

* Read before the Section on Preventive Medicine and Public Health at the Sixty-sixth Annual Session of the American Medical Association, San Francisco, June, 1915.

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[4] Schreyer, O.: Oester-Sanitatswesen, 1911, No. 19.

[5] K. Matsuo: The Simultaneous Appearance of Plague in Man and the Ass on the Same Farm, Centralbl. f. Bakteriol., Orig., 1912, lxv, 417.

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Coal storage piles, dumping tracks and locomotive crane in a surplus supply yard near New York.

The Fuel Supply of a Big Power Plant

Storage of Coal at New York

By J. F. Spinger

JUST about all the coal that comes to New York must, prior to actual delivery or use, be transferred to barges or other vessels for a final short trip by water. The reason lies, of course, in the fact that the great metropolis is, with the exception of a single borough, disconnected from the mainland. And this borough is also practically separated because of the fact that it is on the east side of the Hudson, while the sources of coal lie on the west side.

New York city by itself consumes an enormous yearly tonnage. From its harbor coal is dispatched by boat to New England coast points, and there is a very large business concerned in furnishing bunker coal to vessels sailing from or calling at this port. Counting the entire waterborne traffic, the harbor of New York is probably the second coal harbor of the world, its yearly business falling but little below that of Cardiff in South Wales. Every year, about 25,000,000 tons of anthracite and bituminous coal are transferred from rail to vessel in the American harbor.

The big users of coal in the city are the electric light and power companies, together with the gas and local transportation companies. Among these is the New York Edison Company, which supplies all Manhattan south of 135th Street. This not very large area is probably the greatest user of electricty of its size in the entire world. To satisfy the demands of the 2,000,000 poulation in this district, the company consumes about 600,000 tons of coal per year, or, say, 1,500 tons per day. The great generating station is at Waterside on the extreme east side of Manhattan, about two and one half miles north of the Battery. Coal is received from the railroads at terminal points on the New Jersey shore. Inevitably, there is a considerable water haul. But the physical necessities are increased by those which come from other sources.

It is absolutely essential to the company's operation that there shall be no reasonably avoidable interruptions to its service—especially interruptions due to failure in the coal supply. These may come from natural causes such as storms along the railroad lines, or from strikes at mine or on road, or from accidents, and to avoid these incidents, the company seeks to maintain a reserve of something like a half-year's supply. This means a big storage yard. Under present conditions of the development of coal storage it is very necessary to avoid considerable depths of coal in the storage piles and preferably to avoid wide piles. The reason for this lies in the liability of the deep pile, and perhaps the broad pile, to spontaneous combustion. This is the thing that the big users of bituminous coal have to dread, but adequate precautions usually mean a widespread storage yard. It will readily be seen from the foregoing that a storage yard with a capacity of 200,000 or 300,000 tons would entail on the Manhattan waterfront an excessive real estate investment, so the electric company has its storage yard in New Jersey on the west bank of the Hudson, six or seven miles north of the Battery. The shortest route would lie across Manhattan, but distance is not always the controlling element in the cost of freight transportation. It is undoubtedly very much cheaper to make the longer trip by barge around the southern tip of Manhattan Island than to use both barge and truck on the shorter route.

The storage yard at Shadyside was originally established as an anthracite plant, but is now used for bituminous coal exclusively. Here the coal is brought to the dock, which parallels the river bank, by barge and then stored in the open. The yard may be conveniently described as consisting of two parts. One is rectangular and on the waterfront, the longer sides paralleling the river. The rear part of the yard consists of a more extensive piece of ground on which are four long and parallel piles at right angles to the river.

An automatic tramway encircles the rectangular portion facing the river, and has a long double-track extension at the rear that runs between the two central piles of the rear storage. Two of the rear piles parallel the extension on each side.

The tramway is an elevated railroad operated by an endless cable, which runs on idle rollers or wheels set between rails. Going, the cable and track run north along the dock, then west, then south, then west to a circular turn at the far end of the extension. Returning, the cable and track continue on, coming east on the extension, and then circles around the river front storage space, returning to the starting point from the south.

The cars, which carry two or three tons each, are operated automatically and dump their loads on both sides by doors hinged half way up the body of the car and extending its full length. They are mechanically connected to open and close together. Inside, the bottom

Plan of the Shadyside storage yard and tracks.

of the car consists of a longitudinal ridge. A cross-section of the car would disclose a pretty good letter W. The doors are ordinarily tripped automatically by means of a detachable block secured to the tramway structure.

The cars are provided with a suitable grip for the purpose of frictionally engaging the cable. The grip is set at the beginning of a trip and loosed at the end, and these operations require the attention of an attendant.

The function of the tramway is to furnish transportation between the front of the dock and that portion of the rear storage space that lies beneath the elevated tracks of the tramway extension. The storage piles are more or less removed horizontally from this narrow strip, consequently additional means are required to make the necessary transfers. These are effected by two big locomotive cranes which operate upon a continu-

Cableway car automatically dumping its load.

Movable loading-out hopper over cableway tracks.

ous single track, which extends between the outer and inner piles on either side, and across their ends.

These two cranes have booms about 100 feet long, from which points clam-shell buckets operate to pick up the coal from alongside the tramway and store it in long piles, one on either side of the crane track; or they can take coal from the piles and transfer it to the tram cars for re-shipment to the station in New York.

The front part of the storage yard is served by a movable bridge, which may be shifted up and down the dock. This bridge has an extension reaching out over the water, and the actual handling of coal is done by a clam-shell bucket whose movable point of support is a suitable carriage or trolley.

At the storage yard there are two operations: one concerned with receiving coal—*loading-in;* and the other with discharging coal to barges—*loading-out.*

In loading-in, the loaded barge from the railway terminal several miles to the south is brought up alongside the dock and secured in position. The bridge extension of the hoisting tower is dropped, and the coal is hoisted out of the barge by the clam-shell bucket, which either dumps its load into a hopper over the tramway track, or is traversed along the bridge and deposits its load in the front storage space. An expert operator of the bucket will ordinarily manage the lifting and traversing more or less simultaneously. The bucket will then begin to pass in as it rises in the air. Similarly, in getting the load from the barge, it will usually be the case that the bucket can be started on its drop while on the way out to the barge.

The empty car, as it comes along the dock from the south, will be boarded by a workman, who loosens the grip and halts the car beneath the hopper. It requires but a moment to fill the car, when it will be ready to be dispatched. The operation of seizing the ever-moving cable must, however, not be performed until the workman notes by the position of the car next ahead that the proper interval between cars has been attained. He secures the grip and steps off, ready to take care of the next empty from the south.

The loaded car goes on without attendance, following the line around the curves to the back storage yard. When it reaches a point on the extension, whether on the west-going track or on the east-coming track, where the dumping block has been secured temporarily, the doors will be tripped, both falling open simultaneously, and the coal will be promptly discharged. The car does not stop—there is no need—but continues on its way back to the dock front.

One of the big locomotive cranes standing on its track near the point where the tram car discharges its load scoops up the coal and drops it upon one of the piles on either side of its track as desired, the long boom being swung around as necessary. When loading-out the coal is recovered from the four rear storage piles by the two cranes, or from the dock storage by a clam-shell bucket running back and forth on the bridge. In the former case the assistance of the tramway is employed. In order to facilitate loading the tram cars on the tramway extension, a special movable loading hopper is used. This is mounted on a framework which straddles both tram tracks, and operates back and forth on its own track. While the hopper will be used to discharge over the return tram track, it may be reached by the locomotive cranes from either side of the tramway extension. The tram cars are halted beneath the hopper one by one and loaded for the trip to the dock front. Arrived alongside the dock and barge, the car will discharge into a loading device which receives the coal, and then by means of its conveyor deposits it on board the barge.

Spontaneous combustion is, as already stated, the great enemy to be feared in such plants as that at Shadyside, where the coal is piled pretty high—up to 35 feet, and trouble from fire is experienced here, presumably from this cause. It may surprise those unfamiliar with questions relating to the storage of coal to learn that water is not considered a proper agent with which to fight fires arising from spontaneous combustion. Such fires are apt to be rather deep seated, and the coal above and around the fire will likely be more or less converted into coke, with the result that a protective covering is created. Probably if unlimited quantities of water could be employed the fire could be readily put out with it. Digging the fire out of its nest is one effective method. This is what is done at Shadyside.

Danger from fire might, however, occur from other

Loaded car on way to rear yard.

sources, especially in a plant like that at Shadyside, where provision has to be made for night operation. Crossed wires, broken insulation and the like might very readily combine with other conditions and precipitate much trouble. To light the storage piles and take care

Movable transfer bridge in front yard.

of fire risk constituted a real problem. To provide power and light for the big locomotive cranes was a further one. To avoid interference with the free operation of the crane booms 1,000 candle-power inclosed electric lights have been installed on 40-foot posts set on the outside lines.

Battlefield Casualties

In the figures for the total British losses since the beginning of the war, recently given out by the War Office, the proportion of killed to wounded works out almost exactly in the ratio of one dead for each three wounded. This was for all the forces in all zones and classes of military activity. No differentiation for the casualties in trench warfare has as yet been given out officially, but certain reports indicate that in such warfare about one person is killed to each two wounded. These figures are interesting in comparison with the proportion of 1:4 which had been accepted before the war, and indicates that the kind of warfare which is being conducted bears directly on the amount and character of transportation and hospital facilities required in the zone of such warfare. Our accepted basis for estimates on the clearance of the battlefield will, like so many other standards, doubtless have to undergo material modification.—From the *Military Surgeon.*

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

Gravitation at the Earth's Center

To the Editor of the Scientific American Supplement:

In the article in the Scientific American Supplement of February 19th (No. 2094) by Mr. John Candee Dean it is stated that "the pressure of gravitation near the earth's center amounts to millions of pounds to the square inch, and there matter is reduced to the density of platinum."

In using the term "near the earth's center," does Mr. Dean mean to convey the impression that, so far as the earth is concerned, the force of gravity is greatest at the earth's center and that such force becomes less as the surface is approached?

Or does he mean to imply that the force of gravitation exerted near the center is greater than at the center itself? If the latter, where is the point of greatest force, and how is the result calculated?

Minneapolis. F. L. Moffett.

To the above question Mr. Dean sends the following reply:

To the Editor of the Scientific American Supplement:

In reply to Mr. Moffett's questions, I would say that the force of gravitation is greatest at the surface of the earth and zero at its center. In my article on the *Mysteries of Matter* I say: "The pressure of gravitation near the earth's center amounts to millions of pounds to the square inch, and matter there is reduced to the density of platinum. Under this force liquids yield like a sponge. Owing to the enormous pressure that gravitation imposes on the earth it is compacted into a dense mass as rigid as a ball made from nickel steel armor plate."

We have penetrated but a short distance into the earth's outer crust, and therefore have no absolute knowledge of the condition of matter at the center of the earth. We do know, however, that so far as we have penetrated, the temperature increases and the gravitational force decreases as we go down. We know that the average density of the earth's crust is about three times that of water, while the mean density of the whole earth is 5.53 times that of water. From this it is obvious that the density of matter at the earth's center must be eight or ten times that of water. Prof. A. J. J. See, the celebrated astronomer of the United States Naval Observatory at Mare Island, estimates the density at the earth's center to be equal to that of platinum.

The temperature of the earth appears to increase from the outer surface downward at the rate of one degree Fahrenheit for every 50 or 60 feet, and at the relatively short distance of a very few miles the temperature must be very high. If we disregard the effect of pressure, matter below a certain point would be fused; farther below, matter would be in a gaseous state; still farther down all matter would be at a critical temperature, where there would be no chemical action, and it would be resolved into its simple elements, or in a monatomic condition.

The melting point, however, increases with the pressure. Geologists formerly supposed that the earth was in a molten condition, except the outer crust, but now it is believed to be solid throughout, except possibly for small molten pockets, near the surface. Since the melting point increases with the pressure, and the enormous mass pressing toward the center increases the pressure relatively faster than the increase of temperature, the earth remains a solid body from surface to center. John Candee Dean.

Oxy-Acetylene Welding Practice*

The Welding of Sheet Metal and Boiler Work by the Fusion Method

By S. W. Miller

Sheet metal is used in so many different forms and for such a variety of purposes that it is impossible to give any specific directions in regard to the methods to be followed in welding it. However, some general points can be noted, and the application to specific cases can often be derived from them. It should never be forgotten that in any welded piece there are likely to be strains due to contraction and expansion caused by the heating. In the case of brittle metals, such as cast iron, this strain will probably manifest itself by the piece cracking at some time during the operation or afterward. In the case of tougher metals, such as steel, the strain may not and probably will not so manifest itself, but it will be found instead that the piece will become distorted. The same general principles for taking care of strains in brittle metals apply in the case of tough metals. In other words, contraction must be allowed for in some way, either by preheating, separating the parts, or by expanding some part of the piece by heat or power, etc.

If a piece of steel plate ⅛ inch thick and 6 inches square be heated red-hot in the center with a torch, no particular change will be noticed during the heating, but on cooling off, while no crack will occur as it would if the plate were made from cast iron, the sheet will become badly warped. This warping can be remedied, as is done in everyday practice in boiler or tank shops, by laying the plate on an anvil or solid block of iron and peening it with a hammer until it is straight. This is an operation that requires considerable skill and experience, and is brought to its highest development probably in the case of large circular and band saws used for cutting wood. These have to be "hammered" to suit the speed at which they run and the conditions under which they operate. Without some experience, an attempt to straighten such a piece of steel will result in making it worse than it was originally, and while this process can be used, it is desirable to avoid it if possible. In the case of a small sheet, much of the difficulty can be overcome by heating it red-hot before welding, but in the case of a large sheet, this practice is not feasible, and it is generally difficult, if not impossible, to weld it neatly at the center. However, it is seldom necessary to make such an attempt, the majority of sheet welding being done along the edges, or in other places where the expansion due to the heating can be more readily controlled.

The welding together of short pieces of thin steel may be frequently accomplished nicely by preheating the whole piece along the edges to be welded. If there are many pieces of one kind to do, it will pay to make an arrangement by which a gas burner can be kept under the weld while it is made. In such cases the weld may be tacked at several points along the edges, and if it is kept red-hot by the gas flame it will give very little trouble, and in many cases the distortion will not be sufficient to cause any difficulty. On the other hand, in repair shops, it is not often that many pieces of one kind are done, it being generally odd jobs that are received. In cases where the weld is long, the best plan is to separate the sheets at one end by an amount equal to about 2½ per cent of their length, and just bring them together at the other end. If it is found that the contraction of the weld pulls the sheets together too fast, it will be necessary to hold them apart by clamping, wedging or some other method, forcing the contraction to take place in the weld rather than allowing the sheets to be pulled together. If, on the other hand, the sheets do not come together fast enough, stopping the welding process for a short time will generally correct the trouble, as the sheets cool off and do not again regain the same amount of heat.

It is not possible to clamp thin sheets so tightly that the edges may be brought absolutely together and all the contraction forced to take place in the weld. Even with very powerful clamps it is practically impossible to obtain the same pressure at all points along the edges, and, of course, where the pressure is less the contraction will be greater, the result being a buckling of the sheet and a wavy appearance on finishing the job. One of the easiest ways on odd jobs of this kind is to put a cross of ½ inch round metal between the sheets a considerable distance ahead of the torch, advancing it or moving it back from time to time as the contraction of the weld warrants. This, of course, has its limitations, because when the sheet is very thin, it will bend rather than force the contraction to take place in the weld; but if the sheet are ¼ inch thick or more, it is very satisfactory, particularly if clamps be placed across the sheet in several places, to keep the edges in line vertically.

Another objection to the use of clamps is that unless carefully designed, it is impossible to obtain the same pressure on the sheets twice in succession, and if it is found that a certain pressure with a certain amount of opening at one end will answer the purpose, it is evident that less pressure will cause the sheets to come together too fast and *vice versa*.

In the case of very thin material, such as is used for steel doors in railway passenger equipment, many ingenious jigs and clamps have been devised to hold the parts absolutely in line while welding. They all operate on the principle of forcing the contraction to take place in the weld. As they are special for each type of door manufactured, and as they are too expensive and generally not applicable for repair welding shops, no attempt is made to give any details of their construction, it being sufficient to say that the results obtained by their use are exceedingly satisfactory, and good results could not be obtained without them.

The methods outlined are applicable not only to flat sheets, but also to longitudinal seams of tanks such as range boilers, oil barrels, etc. In many cases automatic welding machines have displaced hand work on such articles and give a regularity of welding, uniform quality and appearance that is not obtained by hand welding. Light sheet welding by hand is really a special trade. The welder must have a steady hand and must keep in continual practice. While such welds made by an ordinary welder would appear to him very regular and uniform, they would seem to the expert sheet welder rather rough and irregular, although they might be perfectly sound. Such welds, if properly made, require very little finishing and result in as smooth a surface after grinding as the original sheet, and also have no buckling or other defects. The thicker the sheet is, the less is the trouble from buckling, and it is generally possible to make a nice appearing and sound weld in such sheets by keeping the wedge of metal between the sheets some distance ahead of the torch as previously explained.

WELDING COPPER AND ALUMINIUM SHEETS.

The welding of sheets of flat metals other than steel is only done in exceptional cases, and while the same principles apply, other metals are generally more ductile, and the strain can be more readily taken care of. It should not be forgotten that all such welds are castings, and except in the case of aluminium, the weld will not be as strong, nor can it be hammered or otherwise worked as safely as the original sheet. Pure rolled sheet aluminium or aluminium sheet with but little alloy can be welded with excellent results, if a satisfactory flux is used, and the resulting weld will be as malleable as the original sheet. Such work is done every day in the case of carriage and automobile bodies, and the metal is afterward beaten over the forms without any difficulty. In the case of copper and brass, proper annealing will help the brittleness of the weld very much, but this cannot always be done, and therefore care should be exercised in subjecting the weld to hammering, rolling, etc.

In the manufacture of steel tanks, there is no special difficulty in welding in the heads. There are, however, a number of precautions that should be observed in the preparation of the pieces, the principal one of which is that they should be so designed as to avoid anything except tensile strain in the weld; that is, no design should be made in which there is any chance of a bending strain occurring due to internal or external pressure. There are two principles to be followed in making such joints: first, that the included angle of the V should be at least 90 degrees; second, that the sum of the edges of the V should be as short as possible. Modifications of these principles may be allowable in special cases, but for all ordinary work they should be strictly followed. In making any welds in tanks subjected to pressure, care must be taken to have the weld made through the sheet, so that there is no crack or remnant of the original edges of the sheet left unjoined.

BOILER WELDING.

The welding of boiler sheets is really a specialty, and should not, except in the simplest cases, be undertaken by a repair shop, unless the welder or the person in charge is thoroughly familiar with boiler construction and the ordinary repair methods. So much depends on the soundness of a boiler that only the very best work is justifiable. Such work can only be obtained from a thoroughly honest, competent welder, who will at all times do the best that lies in his power. Sound welds, free from burnt and oxidized spots and slag, cannot be obtained, even by the best welder, without a good torch; and for this work the best is none too good. It is also almost necessary that the person in charge of the shop be familiar with boiler construction and repairs, so that he, being responsible, may decide intelligently what is to be done, and how.

For such shops as are equipped to do this kind of work, the rules of the Federal Government in connection with marine inspection are an excellent guide as to what may be undertaken in the present state of the art. These rules are, of course, conservative, and in the case of marine work, must be closely followed. The Federal rules are given in the "General Rules and Regulations prescribed by the Board of Supervising Inspectors," copies of which may be obtained at any of the local offices of the Inspection Department, or from the Department of Commerce at Washington, D. C.

The boiler insurance companies must be consulted about the work contemplated in all cases when insurance is carried, as their inspectors would reject it unless the work met with their approval, and the insurance would lapse. As a matter of self-protection, a repair shop should be cautious about boiler welding, because if anything happened later to the boiler, even though it were not the fault of the welding, serious injury might result to the reputation of the shop doing the work.

On the continent of Europe, much greater progress has been made in the welding of boilers than in the United States, and much work is done there that is not yet permitted here. Hence, there is a vast field open to those who are willing to take the time and make the effort to become accomplished welders in this line.

The technique of boiler welding, except in the case of a few specialists, is not yet developed to the point where any one except such specialists should make welds in sheets where the working stress is entirely tensile, such as the shell of any boiler or the roof sheet of a locomotive type boiler. Even the most competent welders, in the author's opinion, should never touch such places, because a crack there points very strongly toward poor design, unsatisfactory material, old age, or overstrain, especially if the defect is near a longitudinal seam and this seam is a single or double riveted lap joint.

There is probably no other important mechanical structure in which more accurate knowledge exists as to the actual stresses involved, and as to the strength of the various joints used than in boilers. This knowledge, however, is unfortunately not as widely disseminated as it should be, and the lack of it (and in some cases the desire to build boilers as cheaply as possible) has resulted in construction that is not good and is sometimes dangerous. These cases are not so common as they used to be, with the result that modern boilers generally give little trouble from defects, unless the boilers are badly treated, or carelessly repaired.

The chance of being called on to make repairs to a boiler, therefore, is generally in the case of one that is rather old. Under these conditions the author always makes a careful examination and if he thinks the boiler is unsafe, he refuses to do any welding at all on it. It is a safe plan for the owner of a defective boiler to have it inspected by one of the boiler insurance companies; and if they will insure it after the welding is done, of course the work can be proceeded with. If they will not insure it, the repairs should not be done.

SIMPLE BOILER REPAIRS.

There are a number of simple boiler repairs that can be readily made, in which the strength of the boiler is not particularly involved, such as welding flue sheet bridges, fire cracks in seams from the rivet holes to the edge of the sheet, etc. In all cases a V should be made entirely through the sheet, leaving the bottom of the V open at least 1/16 inch, so that the metal can be welded from the bottom up. The dirt and scale should be well cleaned off the inside of the sheet as well as the outside. It should not be forgotten that lime or any similar form of scale tends to make a brittle weld. Where one sheet laps over another, as in the case of a fire crack in a seam, the edges of the crack should be raised after beveling by heating somewhat with the torch and driving a chisel underneath. This permits of the weld being made entirely through the sheet. In taking care

* From *Machinery*.

of the contraction after such work, great reliance can be placed on hammering of the weld just after it is made, to expand it, and in fact it is the only simple way with which the writer is acquainted. The hammering must not be continued too long, that is, below a blue heat, or the tendency will be to produce a crack.

Of course fire cracks and broken flue sheet bridges mean short welds, and there is very little chance of leaving a strain in those cases. Where the weld is longer, much judgment must be used in hammering to avoid producing serious strains which may later result in cracking the sheet. Again, there are cases where sheets are corroded in spots. These can generally be built up with perfect safety and to good advantage. Frequently an expensive replacement may be avoided by doing this. However, in such cases, there will undoubtedly be a loosening of the rivets if there are any in the vicinity of the work, and these will have to be replaced or calked to overcome leaks. In some cases it pays to cut out the rivets and redrive them after the welding is done.

Another frequent and rather easy repair is the adding of sufficient metal to a worn calking edge to permit of the sheet being recalked. This can easily be done without welding to the sheet underneath. After the welding is done, the metal may be hammered down and chipped and calked as in the original construction. A small patch can be applied in the corner of a firebox quite readily, but the rivets should be removed for a distance of 8 or 10 inches to allow for contraction.

In a general way there is but little difficulty from contraction in doing welding where there is a change of direction in the surface of the sheet, for example, near a flange or similar bend, because by removing a few of the rivets, the contraction takes care of itself and the rivets can generally be replaced easily. However, in the case of a flat sheet, the problem is entirely different. The welding of cracks in fire-boiler furnaces or fireboxes requires a high degree of skill and knowledge, and generally necessitates the use of special appliances for confining the heat to a narrow zone. Such cracks do not develop singly, but are accompanied by parallel cracks for quite a distance along the sheet. These are frequent in locomotive boilers, and are due to the fact that under severe service the water is driven away from the sheets so that they become overheated. When they are hot, the pressure in the boiler tends to bulge them, causing cracks to appear on the fire side between the vertical rows of staybolts, and on the water side through the centers of the staybolt holes. In the course of time one of these cracks goes through and begins to leak. While there may be no evidence of any more cracks, the bulging of the sheet indicates that there are at least incipient cracks besides the one giving the trouble. Now if the leaky crack be welded, the shrinkage of the weld will open up one of the cracks somewhere in the vicinity, the weld being stronger than the rest of the sheet.

Instances have been cited where a large number of cracks of this kind were welded in one firebox, the result being that finally there was a considerable gap in the last crack that developed, this being, of course, approximately equal to the sum of the shrinkages of the welds. In such a case it may be possible to weld a crack, but the writer does not believe it advisable except for temporary purposes, and then with the distinct understanding that the job is not sound and further trouble will undoubtedly result.

In order to take care of the contraction, it is sometimes the practice to run streams of water or compressed air on the sheet on each side of the crack, about 4 inches from it, thus preventing the expansion due to the heat of the torch and reducing the contraction.

The highest development of the welder's art is needed in the application of patches in the center of a stayed surface, such as a side or flue-sheet of a locomotive firebox. There is no particular difficulty about welding the first side or even the second, but the trouble comes on the third and fourth, particularly on the last one. It is always necessary to use a box patch, that is, one that is dished in the center, so that the dishing will take the strain. Such work, as well as the application of entire side sheets, and patches 12 feet long in large fireboxes, are perfectly possible, and in fact are done every day in locomotive boiler shops, but they are the work of men who are trained in that direction, and they should never be done by any ordinary welding shop. It is therefore unnecessary to give any detailed description as to how this work should be attacked, particularly as the appliances for doing it are special, and have to be modified to suit each case. There is one thing, however, that should always be done in case of any work inside a boiler, or other confined space. An extra man should be stationed at the tanks, which should always be kept outside of the space or boiler, so that in case the hose bursts and the acetylene catches fire, it can immediately be shut off, thus avoiding possible fatal injury to the men inside.

Slag Portland Cement Manufactured From Blast Furnace Slag*

Attention has been turned to utilizing the waste slag from the furnaces to make what is known as slag Portland cement, or in Germany, Eisen Portland cement. Not only is a valuable by-product obtained for which there is a definite market, but also valuable tipping ground is saved. In Germany this industry has attained large proportions; not only have special markets been created for this product, but the Germans have also built up special industries to still further extend the use of this by-product. Many patents have been taken out covering various processes for manufacturing cement from blast-furnace slag, some of these aiming at producing an article little beter than hydraulic lime. While slag Portland cement is not quite as good as the best Portland cement, and consequently commands a lower price, it must be remembered that the raw material in the ordinary course of events is not only a waste product, but costs manufacturers in some cases a considerable sum annually to dispose of; moreover, the cost of power when the gases from the blast furnaces are available is a negligible quantity. Further, owing to the fact that the lime in the slag occurs as an oxide and not as a carbonate, less fuel is required in the kiln; in fact, in a 1,000 tons per week plant, 250 tons less coal per week would be used on a slag Portland cement plant than on a true Portland cement plant using limestone and clay.

The article produced in the most up-to-date process, while not complying strictly with the British Standard Specification for Portland cement, can, with care, be made to closely approximate to it.

In order to treat blast-furnace slags, they should first of all be granulated. The effect of granulating the slag is to cause it to split up into fine sand-like particles; it also has the effect of removing a large percentage of sulphur, and increasing the hydraulic properties of the slag. This granulated slag is then mixed with limestone in the correct proportion, ground and burnt in the kiln, the resulting clinker being again ground to form cement. The chief difficulties that occur are the varying composition of the slags. The composition naturally depends upon the analysis of the ore; in fact, the slags from certain ores are not suitable for the manufacture of cement. Failures of certain plants have been due to the preliminary investigations not having been sufficiently carefully carried out in this respect. The following analysis will give some idea as to the extent of variation of slags:

ANALYSES OF BLAST-FURNACE SLAGS.

	1	2	3	4	5
SiO_2	30.00	30.72	32.51	32.90	31.5
Al_2O_3	28.00	16.40	13.91	13.25	18.58
Fe_2O_3	0.75	0.43	0.48	0.46	.....
CaO	32.75	48.59	44.75	47.30	42.22
MgO	5.25	1.28	2.20	1.37	3.18
CaS	1.90	2.16	4.90	3.42	.....

While 2, 3, and 4 are suitable for use, numbers 1 and 5 are not so suitable.

It is essential that the greatest care be taken to accurately proportion the raw mixture. Special provision must be made for this purpose in all plants. Again, granulated slag is a difficult material to grind finely; failure to appreciate this fact, and to provide satisfactory grinding plant, is also a frequent cause of trouble. The burnt clinker, when ground, probably owing to its high alumina content, is found to be naturally extremely quick setting; this, however, can readily be adjusted, so that any specified setting time can be obtained.

The manufacture of slag Portland cement is usually carried out on the dry or semi-dry process in rotary or vertica kilns. As mentioned above, while slag cements do not comply with the British Standard Specification for Portland cement, the following figures obtained from tests in the writer's laboratory give an idea of the chief features of a good Portland cement, as manufactured at Aberthaw, and a slag Portland cement, as compared with the British Standard Specification:

British Standard Specification for Portland Cement.		Aberthaw "Druid" Brand Portland Cement.	Slag Portland Cement.
Neat (a) 7 days...	450 lbs.	644 lbs.	623 lbs.
Tensile (b) 28 days...	$a + \frac{40,000}{a}$	783 lbs.	729 lbs.
Sand (c) 7 days...	250 lbs.	283 lbs.	207 lbs.
(d) 28 days...	$c + \frac{10,000}{c}$	382 lbs.	280 lbs.
Specific gravity......	Not less than 3.1	3.203	2.96
Expansion..........	....	0.66 mm.	1.5 mm.

In view of the fact that the price of Portland cement is about £2 per ton in Glasgow at the present time, it would appear that this is a subject worthy of the con-consideration of every blast-furnace proprietor.

* From a paper by B. J. Day, read before the Insittute of Engineers and Shipbuilders in Scotland.

Inflammability of Gasoline and of Gasoline Vapor

If one takes the cover off a full pail of tightly inclosed gasoline and applies a match to the surface, the gasoline will flare up and burn as long as the gasoline lasts. On the other hand, if one puts a few drops of gasoline in a small tightly inclosed pail, waits a few minutes, and then introduces a flame or an electrical spark, a violent explosion will most likely result. In the first case the vapor burns as fast as it comes from the gasoline, and mixes with the oxygen of the air. In the second case the oil vaporizes in the pail and mixes uniformly with the air therein to form an explosive mixture and upon ignition explodes. Consequently, when one hears of a disastrous gasoline explosion one may be sure that the explosion resulted from the mixing of the vapor from the gasoline with air in the proportions necessary to form an explosive mixture.

One gallon of gasoline when entirely vaporized produces about 32 cubic feet of vapor. If a lighted match could be applied to pure gasoline vapor in the absence of air no fire or explosion would result. Gasoline liquid or vapor, like any other combustible material, needs the oxygen of the air in order to burn.

It is fortunate that gasoline vapor, like other gases and vapors, needs a certain proportion of air before an explosion can take place. The author found that in 100 parts by volume of air and gasoline, an explosion will not take place if there is less than 1.4 parts of gasoline vapor or more than 6 parts.* In other words, the explosive range is between 1.4 and about 6 per cent of vapor. Flashes of flame will appear in mixtures containing considerably smaller and larger proportions of vapor, and considerable pressure will be developed, but propagation through the mixture will not take place.

Although the range of explosibility mentioned is narrow as compared to that of many other mixtures of combustible gases and air, yet the proportion of gasoline vapor representing the lower limit is small, and indicates the great importance of not allowing even a little gasoline to be exposed in a room, because of the small quantity of vapor needed to make an explosive mixture with all the air in the room. If 1 gallon of gasoline is allowed to change completely into vapor simply by exposing it to the room air, and if the room is gas-tight, the 1 gallon can render explosive 2,100 cubic feet of air, the amount contained in a room measuring 21 by 10 by 10 feet.

In the actual use of gasoline such conditions seldom exist. However, an assumed case may be that of a person filling an open pail from a larger tank or using gasoline for cleaning. When the pail is first filled with the gasoline, a small volume of pure gasoline vapor forms over the surface of the gasoline. Just above this layer of pure gasoline vapor is a mixture of vapor and air; at some point there will be an explosive proportion, and farther away from the pail there will be a small proportion of vapor, and finally still farther away no vapor at all, but pure air. However, all the time the user of the gasoline is at work, the vapor keeps forming, from both the gasoline in the pail and that applied to the object being cleaned, rendering more and more air inflammable or explosive, until finally there will exist a dangerous atmosphere that may completely surround him, so that a chance ignition will envelop him in flames and perhaps cause great damage to property. Ignition of the gasoline vapor may take place even some distance from the gasoline in a room adjoining the room in which the person works. As the gasoline evaporates, and more and more vapor is given off, it mixes with air farther and farther from the gasoline and, if the evaporation lasts long enough, may travel to an adjoining room, where it may be ignited. On ignition a sharp flash will travel back through the adjoining room to the room where the gasoline is.—*Technical Paper 127, Bureau of Mines.*

Thermal Instrument for Current Measurements

If a horizontal tube filled with alcohol, and containing an air bubble, is heated at one end the bubble will move toward the point of higher temperature. It has been suggested by writers in *The Electrician* that this principle may be utilized for measuring electric currents, and to secure a definite zero point the tube should be bent in the middle, the two arms making an angle of 170 degrees. The bubble will then remain stable at the bend. If the tube is mounted on a base hinged at one end, the bubble can be brought back to zero by a screw having a vernier head, when displacement is induced by an electric current, and the current thus measured. The motion of the bubble is due to change of surface tension with temperature.

* Burrell, G. A., and Boyd, H. T., Inflammability of mixtures of gasolene vapor and air: Technical Paper 115, Bureau of Mines, 1915, p. 10.

Effect of Light on Plants*

A Study of Plant Action Under Various Conditions

In the whole realm of biological science there is perhaps no phenomenon of greater fundamental importance than that exhibited by green plants in the transformation of carbon dioxide and water into starch and sugar. That this can only take place through the action of light upon chlorophyll is commonplace knowledge, but exactly how it is affected we do not know. Of the light that falls upon a green leaf a part is reflected from its surface, a part is transmitted, and another part is absorbed. That which is reflected and transmitted gives to the leaf its green color; that which is absorbed, consisting of certain red, blue, and violet rays, is the source of the energy by means of which the leaf is enabled to carry on its work.

The extraordinary molecular complexity of chloro-

Fig. 1.

phyll has recently been made clear to us by the researches of Willstätter and his pupils; Usher and Priestley and others have shown us something of what takes place in chlorophyll when light acts upon it; and we are now beginning to realize more fully what a very complex photosensitive system the chlorophyll must be, and how much has yet to be accomplished before we can picture to our minds with any degree of certainty the changes that take place when light is absorbed by it. But the evidence afforded by the action of light upon other organic compounds, especially those which, like chlorophyll, are fluorescent, and the conclusion according to modern physics teaching that we may regard it as practically certain that the first stage in any photo-chemical reaction consists in the separation, either partial or complete, of negative electrons under the influence of light, leads us to conjecture that, when absorbed by chlorophyll, the energy of the light-waves becomes transformed into the energy of electrified particles, and that this initiates a whole train of chemical reactions resulting in the building up of the complex organic molecules which are the ultimate products of the plant's activity.

The absorption of light by the leaf is therefore of great physiological importance, and we have only to look at any of the plants around us to see how successfully they contrive to arrange their leaves to obtain the maximum advantage from the light that falls upon them. A plant

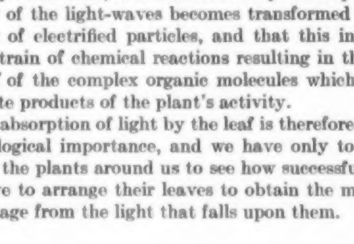

Fig. 2.

organ responds to the directive influence of light by a curvature which places it either in a direct line with the rays of light as in grass seedlings or at right angles to the light as in ordinary foliage leaves.

Formerly it was thought that the light acts directly on the part that bends, but the researches of C. and F. Darwin more than thirty years ago proved that in young seedlings this is certainly not the case. They showed quite conclusively by means of a large number of carefully contrived experiments that the heliotropic curvature in the lower part of a seedling is determined by the illumination of the upper part. Consequently no curvature can take place until a stimulus has been transmitted from the upper part, which behaves as a light-perceiving organ, to the lower part, in which the motor response takes place.

Foliage leaves are not usually so sensitive to light as the plumules of young seedlings, and do not in many respects so readily admit of experimental investigations. We know that the leaf-stalk bends toward and tends to place itself parallel to the rays of light, and that the leaf-blade places itself at right angles to the rays of light. We know that when the leaf reaches the position of maximum advantage the movement toward the light ceases, and it then remains fixed, except for slight circumnutating movements, until either the direction of the light changes or its intensity is decreased. But we do not yet know—and the problem is not an easy one to solve—by what means the leaf is enabled to adjust its position to the direction of the rays of light, nor just how it perceives that it is or is not in the most advantageous position.

Dutrochet suggested, without any experimental evidence to support it, that the lamina of the leaf exerts an influence on the movement of the leaf-stalk. Hanstein also considered that the lamina was the light-sensitive part of the plant, and even went so far as to compare it with the retina of the eye. C. and F. Darwin were the first to attempt to determine the point experimentally.

Pieces of blackened paper were gummed to the edges and over the blades of some leaves on young plants of *Tropaeolum majus* and *Ranunculus ficaria*; these were then placed in a box before a window, and the petioles of the protected leaves became curved toward the light as much as those of the unprotected leaves.

Rothert repeated Darwin's experiment on Tropæolum, and found that the leaves reach the right position whether darkened or not. Krabbe also showed by his experiments on Phaseolus and Fuchsia that when the leaf-blades were darkened the leaves reach the right position just as readily and as precisely as the undarkened leaves. On the other hand, Voechting came to the conclusion from his experiments on Malva that the curvature of the leaf-

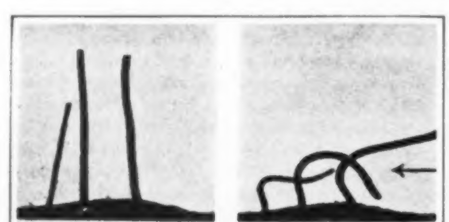

Fig. 3.

stalk only followed when the blade of the leaf was illuminated.

Haberlandt concluded from his experiments on a variety of leaves that in some cases the lamina is the only percipient organ, that in others both lamina and leaf-stalk are concerned, and that in very few cases is the leaf-stalk or pulvinus alone responsible. He considers that when both lamina and leaf-stalk are concerned the larger movement is probably brought about by the leaf-stalk and the finer regulating movement by the lamina.

The experiments which I am about to describe are concerned in the first instance with the problem: Does the lamina perceive the light, or is the leaf-stalk the percipient organ, or do both take part in it?

The observations were carried out by a method suggested by the extremely ingenious and charming device employed by F. Darwin to prove that the geotropic sensitiveness of the plumule of a grass seedling is localized at the apex. It consists essentially in keeping the blade of the leaf fixed while the petiole is free to move. Thus if the blade of the leaf is kept in a horizontal position and then exposed to oblique light, what effect will be produced on the petiole? If it is free to move, the petiole ought to curve toward the light; and if the stimulus is localized in the leaf-blade, the curvature ought theoretically to continue so long as the stimulus continues to act and the petiole is capable of growth.

The experiment was first of all tried with a number of leaves of *Eranthis hiemalis*. The leaves were carefully removed from the plant; the blades were then attached to a glass plate, and the stalks were allowed to hang downward in a glass vessel containing water. On the exposure to an oblique lateral light the stalks very soon began to curve toward the light, and continued to curve in the same direction for several hours until in many cases a complete spiral was formed (Fig. 1). Similar results were obtained with the leaves of many other plants. If a leaf in the petiole of which this heliotropic curvature has been induced is turned round so that the light impinges upon it on the opposite side, the curvature becomes reversed (Fig. 2).

The advantages of this method are that the leaves are not submitted to the rough treatment necessary to darken the blades or stalks, and, secondly, there is less interference with the respiratory and assimilatory functions. The disadvantages are that the leaf-stalks, being free to move, may be stimulated by gravity, and the pronounced curvatures thus induced may, unless proper precautions are taken, be mistaken for phototropic curvatures. So long as it is approximately vertical, the leaf-stalk is not influenced, or only slightly, by gravity, but immediately it moves from the vertical in response to the light stimulus, the influence of gravity comes into play, and light in conjunction with the gravitational

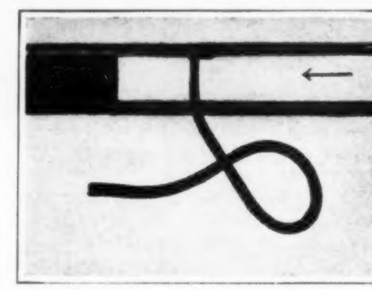

Fig. 4.

stimulus takes a share in affecting its curvature. As soon, however as the leaf-stalk in its upward movement passes beyond the vertical, the gravitational stimulus tends to bring it back to the vertical position, and the light stimulus then, in order to effect any further curvature, has to continue its action against the force of gravity.

A striking experiment to show that curvatures may be effected by the phototropic stimulus against the gravitational stimulus was made by placing leaves upside down. Three young leaves of *Eranthis hiemalis* had their leaf-blades securely fixed between two pieces of black cardboard, the leaf-stalks passing through small holes in one of the pieces of card. The leaves were then placed with the stalks projecting upward in water in a rectangular glass vessel. Three sides of the glass were darkened, the other side was exposed to a dull lateral light. In the course of the day (Fig. 3) the stalks curved distinctly toward the light against the force of gravity which tends to keep them vertical.

In all these experiments the light was allowed to act upon the whole of the leaf, both blade and leaf-stalk, but as in many cases the leaf-stalk itself is phototropically sensitive, it was important to determine to what extent either of these organs, submitted separately to the influence of light, might bring about the curvature. Accordingly, experiments were made by which the leaf-

Fig. 5.

blades only were exposed to oblique light. This was done by fitting a light-tight cover over an opaque vessel containing water. The stalks of the leaves were passed through small apertures in the cover and allowed to hang down in the water. The blades resting on the surface of the cover were then covered with a piece of clear glass and exposed to the light. After some time the stalks were found to be curved more or less in different directions, no doubt due to the geotropic stimulus, but there was no definite curvature toward the light, although in many experiments the leaves were exposed to the light for a week and even longer.

When, however, the leaf-stalks are exposed to the light and the blades kept in the dark, the stalks all curve distinctly to the light. A large number of leaves belonging to different families of plants was tested in this way, and the result was always the same. The conclusion therefore seems justified that the perception of light is located not in the leaf-blade but in the leaf-stalk.

The further problem then arises: Does the whole of the leaf-stalk perceive the light or only a portion of it? Have we in the leaf-stalk, as found by C. and F. Darwin

* A discourse delivered before the British Association at Manchester by Dr. Harold Wagner, F.R.S.

in the plumules of seedlings, a percipient region and a motor region separated from one another? To answer this question a simple piece of apparatus was devised, consisting of a shallow box about 10 millimeters high, with a thin base and a thin top, leaving a space of about 7 or 8 millimeters between them. This was open at one end, and fitted light-tight over an opaque vessel containing water. Through small holes in the top and bottom of the box the leaf-stalks were passed, so that the lower portions were in the dark, the upper 7 or 8 millimeters at the apex of the leaf-stalk being exposed to the light. The leaf-blades resting on the upper surface of the box were covered with a piece of black card, and the apparatus was then placed in such a position that light rays entered the box and impinged upon the upper part of the leaf-stalks only. Before the experiment was started, however, in all cases the stalks were allowed to stand for some time in the dark until geotropic curvatures were set up; the position of the leaves was then so adjusted that the darkened parts of the leaf-stalks were all curved in the opposite direction to that of the light incident upon the upper parts.

Under these conditions the heliotropic stimulus was acting in opposition to the geotropic stimulus. The results obtained were most striking. The curvature toward the light was very marked, and distinct spiral curvatures were produced (Fig. 4).

From experiments made in this way on a large number of plants it was found that the apex of the leaf-stalk for a distance of a few millimeters behaves as a percipient region, and is capable of inducing a motor response in the lower part. Experiments were made to determine how much of the apical region it is necessary to expose to the light in order to obtain a response. Leaves of *Geranium pratense* and *Tropaeolum minus* were arranged to allow different lengths of the apex, 1, 2, 4, 6, 8, and 10 millimeters, respectively, to be exposed to the light. A distinct response was obtained in each case, but the most definite results were obtained with lengths of from 4 to 10 millimeters.

We have now to consider briefly the mechanics of the movement. The curvature of the stalk is brought about by a more rapid elongation or growth on one side. The tissues of which the stalk is composed are all in a state of strain. The pith and vascular cylinder tend to expand, the cortical tissues to contract. Consequently if the stalk is split down the middle the two halves curve outward, and, if placed in water, may coil up into a spiral. Now, how does the phototropic stimulus affect this state of strain? What will be the effect of splitting a leaf-stalk that has become curved under the influence of light? Will the two halves coil themselves up in opposite directions as before, or will it be found that the tensions have become modified, and the curvatures also modified in consequence? The experiment was tried on a number of different leaves, and it was found that in all cases the posterior half of the leaf-stalk retains the heliotropic curve, but the end of it tends to coil backward as before. It is obvious that the light stimulus brings about a permanent change by which the relationships of the tissues to one another as regards their tensions are modified.

Now what will happen if a stalk is split before the heliotropic stimulus is applied? Will the stimulus affect the two halves, or will the posterior half remain unchanged? To investigate this a leaf-stalk of *Geranium pratense* was split to within 8 millimeters of the apex. The unsplit part then exposed to light, the blade, and the lower portion of the stalk being kept in the dark. The result shows (Fig. 5) that the stimulus received by the upper part of the stalk is transmitted to both halves, and the posterior half curves in the direction of the light. The end of the posterior half is, however, coiled backward as before.

If we split a stalk into four we get the same result (Fig. 6); all the four separate parts of the leaf-stalk curve quite distinctly to the light.

Now arises the further interesting problem. If the leaf-stalk is split right up to the apex, will any effect of light be produced in the posterior half? A leaf-stalk split up to the apex was immersed in water for some time until a distinct spiral curvature was produced in both halves. The upper 8 millimeters of the two halves were then exposed to light, one half being in front of the other, the blade and remainder of the stalk being kept in the dark. At the end of several hours' exposure to light, not only was the anterior half much coiled—due to the heliotropic stimulus and turgescence of the pith acting together—but the posterior half also showed a distinct curvature to the light in the motor region (Fig. 7). We find, therefore, notwithstanding the fact that two halves of the percipient region, the anterior and posterior, are completely separated from one another, that the posterior half receives a stimulus as well as the anterior half, and that this determines in it a definite heliotropic curvature. Some attempt was then made to determine (1) what tissues of the stalk are concerned in the perception of light, and (2) the tissues through which the stimulus is conducted. In the first place, the epidermis of the stalk was completely removed and the upper 10 millimeters of the stalk then exposed to the light, leaving the blade and the rest of the stalk in darkness. After several hours a definite curvature to the light was obtained, although not so pronounced as in an uninjured stalk. This was probably due to the rough treatment to which the stalk had been submitted by scraping off the epidermis. The experiment, however, shows that the epidermis is not essential either for the perception or the transmission of this stimulus.

Another leaf was then taken and the epidermis together with a part of the underlying cortex removed. In this case also, when the upper part of the stalk was exposed to the light, a definite curvature was obtained. Another leaf had the epidermis and the whole of the cortex removed, but in this case, even after an exposure of three days, no definite curvature to the light was obtained. These experiments indicate therefore that the cortical tissues are those mainly concerned in the perception and transmission of the stimulus. Further, several leaves were taken and transverse incisions were made on opposite sides of the stalk so that the tissues were completely cut across. Here also a distinct but not very pronounced curvature to the light resulted. It thus appears that although the perception of light is located in the cortex

Fig. 6.

the stimulus can be to some extent transmitted transversely through the tissues, probably through the parenchyma and pith. That the pith is not necessary, however, was proved by splitting the leaf-stalk longitudinally into two halves and then removing by means of a sharp scalpel the whole of the pith, together with some small portion of the vascular bundles. On exposing the upper part of the stalk thus treated to the light, a definite curvature was obtained in both halves of the stalk.

It appears, therefore, from these experiments that the perception of light is located, probably, mainly in the cortex, but that the transmission of the stimulus may

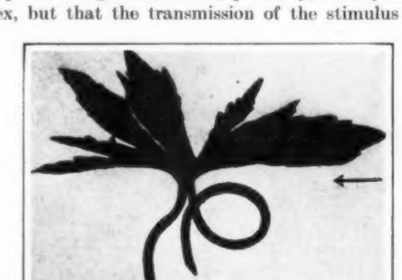

Fig. 7.

be conducted both longitudinally and transversely through any of the parenchymatous cells of the stalk, and that the motor response, although much more definite and pronounced when the whole of the cortex is present, can also take place when this is partly removed.

We may now ask, What is it that the leaf perceives, the direction of the light rays or the difference of intensity and the illumination on the two sides of the leaf? We cannot answer this question decisively; it is probable that both hypotheses are to some extent correct. When the stronger light falls upon one side of the leaf-stalk, those cells on the side which is more illuminated are stimulated to activity to a greater extent than those on the less illuminated side, and the stimulus is transmitted to the motor region. Inasmuch as this stimulus is due to physico-chemical changes set up in the cells nearest to the light, the plant may be said to perceive a difference in the effects produced by the light on the two sides—that is, it is able to compare the two intensities. As soon, however, as the leaf reaches its right position, the apex of the stalk is illuminated more or less equally on all sides, and as the physico-chemical changes in the cells may now be considered to be more or less equal, no further stimulus will be transmitted, or, if so, will be transmitted equally all around the stalk, and no curvature in either direction will take place. The leaf now being placed in a definite position with reference to the direction of the light rays, it would seem quite justifiable to conclude that the plant is capable of perceiving the direction of the rays of light.

But the leaf is also capable of distinguishing between light of different wave-lengths. Notwithstanding the fact that rays of light both at the red end and at the blue end of the spectrum are absorbed, the plant responds phototropically mainly to the rays at the blue end of the spectrum, very slightly, possibly, in some cases to the red rays. This has been demonstrated by keeping plants behind different colored light filters, and also in different parts of the spectrum. That this power is localized in the percipient region at the apex of the leaf-stalk can be very easily proved by exposing this percipient region to rays of the blue or red color. The filter prepared and spectroscopically examined by Messrs. Wratten and Wainwright can be used for this purpose. Experiments were made with blue, green, and red filters. A strong curvature took place under the influence of the blue rays, but no curvature under the influence of the green or red rays, even when the exposure was continued for more than a week.

Here we have to do, therefore, with the quality as well as with the intensity and direction of the light rays, and the fact that the plant is more sensitive heliotropically to the shorter and more frequent vibrations at the blue end of the spectrum than to the longer and less frequent vibrations at the red end, indicates that it cannot merely be the direction of the light rays that is perceived. Moreover, we must remember that the plant does not respond directly to the action of light, but to the physico-chemical changes that take place in the photo-sensitive cells of the percipient region. We, ourselves, perceive the light because the brain is able to translate into sense impressions the physico-chemical changes which take place in the elements of the retina. The plant perceives the light because it is able to translate into a motor response the physico-chemical changes taking place in the photo-sensitive cells of the perceptive region.

We may imagine that in the plant the action is as follows: The light is absorbed by, and excites, certain photo-active substances in the cells of the sensitive region. A stimulus is thus set up which is conveyed through the cytoplasmic fibrils of the protoplasts to the motor region. A further impulse is then set up which acts upon the cells in the motor region, by which it is probable that changes in the permeability of the protoplasts are effected; the turgor conditions of the cells are thereby differentially altered, and the result is a motor response. We have here, in fact, a very simple type of reflex act taking place through the agency not of highly specialized nerve-cells, but of ordinary protoplasm and of the delicate protoplasmic fibrils which extend from one cell to another.

How the U. S. Geological Survey Contributes to Public Health

The geologic resource of greatest value to the health of communities is a supply of pure drinking water. It is generally recognized that a number of diseases, prominent among which are typhoid fever and amœbic dysentery—a disease more common in tropical climates but found also in the United States—are contracted through contaminated water or contaminated food. Therefore a supply of pure water will eliminate one of the sources of such infection.

It is highly desirable to obtain supplies of domestic water from sources other than the shallow wells, some of them open, that are found near many houses. The water obtained from deep wells has percolated through sands and other material for so great a distance that its impurities have been removed by filtration, and it possesses a sanitary value that cannot well be overestimated, for such water is free from the bacteria causing typhoid fever and the protozoa causing amœbic dysentery, and its use obviates the necessity for shallow wells that may serve as a breeding place for Anopheles, the mosquito to which malarial infection is due.

The United States Geological Survey for a number of years has been prosecuting, largely in co-operation with the State surveys, a systematic study of the ground-water resources of all the Coastal Plain States.

With good health recognized as one of the great national assets, the extent of this study of underground-water resources furnishes a measure of its value to the public. Reports have been published covering 376,000 square miles in the Atlantic and Gulf States, reports on 27,000 square miles are completed though not yet published, field work has been completed on 50,000 square miles, and work is contemplated to cover 16,000 square miles. These areas of nearly half a million square miles include the parts of the United States in which impure water supplies involve the greatest danger. The value of such surveys in conserving public health has been demonstrated, for it has been noted that wherever a supply of deep-well water has been obtained, typhoid fever, amœbic dysentery, and malaria have abated.—*Report of Geological Survey, 1915.*

Insects and War—II*

Some Characteristics of Nuisances That Are Also Known in Times of Peace

By Arthur Everett Shipley, Sc.D., F.R.S.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2098, Page 192, March 18, 1914

THERE are one or two structural features in a flea which are peculiar, the most remarkable being that, unlike most other insects, it is much taller than it is broad. As a rule, insects—such as a cockroach, the bed-bug, or a stag-beetle—are like skates, broader than they are tall; but the flea has a laterally compressed shape, like a mackerel or a herring. Then, again, the three segments or rings which come after the head are not fused into a solid cuirass or thorax as they are in the fly or the bee, but they are movable one on the other. Finally, it is usually in insects for the first joint of the leg to be pressed up against and fused with those segments of the body that bear them; but in the flea, not only is this joint quite free, but the body segment gives off a projection which stretches out to bear the leg. Thus the leg seems, unless carefully studied, to have an extra joint and to be—as, indeed, it is—of unusual length. They certainly possess unusual powers of jumping—as Gascoigne, a sixteenth century poet (1570-78) writes: "The hungry fleas which frisk so fresh."

The male, as is so often the case among the invertebrata, is much smaller than the female. The latter lays at a time from one to five minute, sticky, white eggs, one fortieth of an inch long by one sixtieth broad. They are not laid on the host, but in crevices between boards, on the floor, between cracks in the wainscoting, or at the bottom of a dog-kennel or in birds' nests. Mr. Butler recalls the case of a gentleman who collected on four successive mornings sixty-two, seventy-eight, sixty-seven, and seventy-seven cat-fleas' eggs from the cloth his cat had slept upon. Altogether 284 eggs in four nights. The date of hatching varies very much with the temperature. *Pulex irritans* takes half as long again—six weeks instead of four—to become an adult imago in winter as it does in summer. But in India the dog-flea will complete its cycle in a fortnight.

When it does emerge from the egg the larva is seen to be a whitish segmented little grub without any limbs, but with plenty of bristles, which help it to move about; this it does very actively. There are two small antennæ and a pair of powerful jaws, for the larva does not take liquid food, but eats any scraps of solid organic matter which it comes across; dead flies and gnats are readily devoured. The larva casts its skin several times, though exactly how often it molts seems still uncertain.

After about twelve days of larval existence it spins itself a little cocoon in some sheltered crevice, and turns into a whitish inert chrysalis or pupa. During its pupal existence it takes, of course, no food, but it grows gradually darker, and after undergoing a tremendous internal change, breaking down its old tissues and building up new ones, the chrysalis-case cracks and the adult flea jumps out into the world.

Perhaps the most important of biting insects is the mosquito, certain species of which convey malaria—a disease which has probably played a bigger part in the history of the world than that conveyed by any other insect. As in most other biting insects, the piercing organ consists of a tube, or gutter, in the hollow of which lie certain chitinous rods, with saw-like edges, and the outer gutter incloses an inner gutter facing the other way, up which ultimately the blood the mosquito sucks will flow. In the mosquito there is also a median structure, like a double-edged sword, the prolongation of the lower lip. This is traversed by the duct, from which flows the so-called saliva of the insect. This saliva carries with it the microscopic, unicellular animals which cause malaria, and down this minute, microscopic duct has flowed the fluid which has altered the fate of continents and played a conspicuous part in destroying the civilizations of Greece and Rome.

The female is very voracious, but the mouth parts of the male are not strong enough to penetrate the human skin; it has to be content with a diet of vegetable juice. Still, the female will suck up blood till all the cracks between its chitinous armor are incarnadined. It is thought by some that no eggs are laid unless a meal of blood has been taken. This, however, does not seem to have been definitely established.

Anopheles maculipenis is the chief carrier of malaria, and is found very widely distributed throughout the world. As a rule, individuals do not wander very far on their own account, but they can be blown considerable distances by a wind, and they have a habit of traveling about in trains and ships, but not, perhaps, to the same extent as *Stegomyia calopus*, which conveys the yellow fever. The female hibernates throughout the winter, and has been found under the frozen snows of Siberia, mingled with the moss and snow. In England they are frequently found in old out-houses, deserted cellars, and unused farm buildings. They have generally left their winter quarters by May, when they begin to lay their eggs, and this they do early in the morning. In temperate climates there are three or four generations during the summer, the latest being through September and October. It has been calculated that if the number of eggs laid by the female be 150, the numbers of the descendants by the fourth generation would amount to over thirty million. This may account for the enormous numbers in which mosquitoes are found in Finland, Siberia, and other northern climates.

The eggs are rather like little lifeboats, with a floating ridge on each side which keeps the ova the right way up. They are black with a certain iridescence, and, like all other objects floating on the surface, they tend to form star-like or reticulated patterns, and if they are near where the water touches the edge of the vessel they are drawn a little way up. But the head-end of the egg always points downward, so that should the larva emerge while in this position it at once gets into its proper element. The larva emerges during the second or third day after oviposition, according to the temperature. It is one of the most interesting aquatic larvæ we know. It hangs on the lower surface of the surface film by a series of palmate hairs; and by its open stigmata, which pierce the surface-film, it puts the interior of the body in connection with the atmosphere. The head is provided on its under surface with two moustache-like structures, which constantly sweep the under surface of the surface film, sweeping the organic matter which may have floated up there into the larva's mouth. Since the dorsal surface of the larva is uppermost, and the brushes are on the ventral surface of the head, when feeding the head is turned round at an angle of 190 degrees, and this is done with so much precision that you can almost hear it click. The pupa is also attached to the surface film by its breathing trumpets, and it is these stigmata, or breathing pores, that are the weak point in the structure of these diptera, since it is easy by brushing paraffin through the water to establish a thin surface film of oil, which cuts both larva and pupa off from the necessary oxygen, and so kills them.

Stegomyia is somewhat different in appearance. It is especially a haunter of the dwellings of man, and it frequents ships. Its egg is covered with a series of reticulations containing air which enables it to float, and the larvæ, unlike those of *Anopheles*, but like those of *Culex*, hang down into the water by single respiratory stigmata.

They seem to bite all the twenty-four hours round, and although we have not been able to isolate the organisms which cause yellow fever, there is no doubt the fever is conveyed by this species of mosquito.

There are also a number of biting flies, such as the *Tsetse* fly, which sucks blood greedily, and the blood-sucking maggot of a fly, a larva of *Auchmeromyia luteola*, which chiefly affects natives sleeping on mats in Central sub-tropical Africa, and there are, of course, many flies which injure horses and cattle, and materially diminish the value of their hides. Leather plays a very conspicuous part in warfare. The deterioration of hides owing to the warble fly very materially affects the leather market, not to mention the fact that when cattle are attacked the meat is also seriously damaged.

Let us turn now for a few minutes to the insects that affect the food of man. Both the house-fly and the blue-bottle fly act in this manner.

In our country house-flies usually begin to breed in June and July, continuing well on into October if the weather be but warm. Their greatest activity is, however, in the hotter month of August and the beginning of September. But in warm stables, restaurants, and kitchens, flies are able to reproduce the whole year round. A single fly will deposit at one time 100 to 150 eggs, and in the course of her summer life may produce five, or even six, batches of ova of this size. The eggs are pearly white, elongated structures, with two converging lines, along which the egg-case will ultimately spit to give exit to the larva. The eggs are laid, by means of a long ovipositor, a little way beneath the surface of the dung-heap in a position where they will not readily be dried up. In favorable conditions the eggs hatch in from eight to twenty-four hours.

The larvæ are legless, tapering toward the head, which bears a pair of breathing-holes, or spiracles; their bodies are much stouter toward the hinder end. On the whole they are white, unpleasant looking maggots, called by fresh-water fishermen "gentles." By contracting and expanding its body it pushes its way through the moist, semi-liquid surroundings. The skin is usually molted some twenty-four hours after birth, but all these time limits depend much upon the temperature and favorable conditions. With normally high temperatures—say, with 86 deg. to 95 deg. Fahr.—the larva will become fully grown in five or six days. The third and final stage, after the second molt or ecdysis, lasts three days, and when fully grown the maggots are about half an inch in length. Externally, twelve segments are visible, but the internal anatomy shows that thirteen are really present, though one is almost "masked."

It is only during these larval stages that the insect grows, and it is never more bulky than in the third larval stage. Now it leaves the moist situation in which it has flourished, and, crawling through the manure, seeks some dry or sheltered corner near the surface of the manure heap. For a time it rests, and then after an hour or two's quiescence it retracts its anterior end and assumes a barrel-shaped outline, its creamy white color slowly changing to a mahogany brown. The larval skin forms the pupa-case, and within this pupa-case the body of the larva undergoes a wonderful change, far greater than ever human beings undergo at the time of puberty. Many of its organs are disintegrated and re-formed, and in the course of three or four days the white, legless, repellent maggot, who "loves darkness rather than light," is changed into a lively, flying insect, seeking "a place in the sun" and the companionship of man. As the Frenchman said of the pig which goes into one end of the machine in the Chicago meat factory as live pig and comes out at the other end in the form of sausages, *"Il est diablement changé en route."*

In a very short time after leaving the pupa-case the adult fly has stretched her wings, the chitin of her body has hardened, and she flies away "on her several occasions."

Flies become sexually mature in a week or ten days after emerging from the chrysalis-case, and are capable of depositing their eggs four days after mating, so that if the conditions be indeed favorable the whole development from the egg to the perfect fly may be accomplished in nine or ten days, and the second generations are able to lay their eggs ten days later. The appalling fecundity of such an insect explains the fact that in the hotter parts of the world nearly every edible thing seems to be covered with flies.

The proboscis of a fly can only suck up liquid food; and when we see it feeding on solid substances, such as sugar, it has really dissolved the sugar by depositing some saliva on it, and is sucking up the sugary solution so produced. It not infrequently regurgitates its food in a spherical drop, which it generally reabsorbs.

As we have seen, flies are very susceptible to temperature, and with the approach of cold weather they seem to die. We used to think that some, in a state of suspended animation, "carried on" through the winter months. This is, however, "non-proven." Many of them undoubtedly die in the autumn, as bees die, of old age. They are literally worn out. But a great number fall victims to a parasitic fungus called *Empusa*. Flies killed by this fungus are frequently to be seen in autumn, hanging dead on windows, etc., surrounded by a little whitish, powdery ring of spores formed by the fungus.

Flies, like many other common insects, are extremely difficult to keep alive in captivity, and few have succeeded in rearing them for more than a month or two. At one time, as we have said, it was thought that those flies which survive the winter were fertilized females of the younger broods, and that during the winter they subsisted on their "fat bodies."

Doubt, however, has recently been thrown on this theory, and at the present time, as the Local Government Board states, the manner in which the interval between one fly season and the next is bridged over still remains unsolved.

Flies breeding in horse manure, or coming direct from infected organic matter, affect the jam, the milk and other food of the soldier. Until the perfecting of

* A paper read before the Royal Society of Arts.

the anti-typhus inoculation was effected, in times of war typhoid killed more soldiers than bullets. Infantile diarrhœa is another disease associated with *Musca domestica*, so are ophthalmia and anthrax.

It will be noted that the fly acts simply as an inoculating agent. The germs which are conveyed are mostly bacteria, and they do not necessarily undergo any change in connection with the body of the house-fly.

Next we come to a series of insects which affect the food of soldiers and sailors. One is the flour-moth, *Ephestia kuhniella*, whose larva burrows through the soldiers' biscuit and not only consumes a considerable portion of it, but renders it so unpalatable that Sergeant Daniel Nicol, of the Ninety-second Gordon Highlanders, tells us that, during the Expedition to Egypt in 1801, "some vessels were dispatched to Macri Bay for bullocks, and others to Smyrna and Aleppo for bread, which was furnished us by the Turks—a kind of hard dry husk. We were glad to get this, as we were then put on full rations, and our biscuits were bad and full of worms; many of our men could only eat them in the dark." The biscuits become infected during the cooling which takes place between the baking and the packing. The adult insect, *E. kuhniella*, is a perfect nuisance in flour-mills. So persistent and numerous are these moths at times that they clog the rollers with their cocoons, and sometimes completely stop them. The webbing of the elevators in the mills gets covered with them, and with their silky skeins, and then the elevators stop working. They mat together the flour and meal with their silken excreta, and so uniform is the temperature of the mill, and so favorable to the life of the insect, that they complete their life-cycle in this country in two months, and in the warmer parts of America even more rapidly. In well-heated mills the proceeding is continuous, so that six generations at least may be produced each year.

Now that the war is spreading in the Near East, a word or two should also be said about an allied species of insect, *Ephestia cautella*, which infests at times 50 per cent of the figs of the East. It is a moth which is spread all over the world, and is catholic in its taste, since it flourishes on rice, bran, dried apples, maize and a great many more or less nutritious foods. It lays its eggs in the figs while they are being dried in the sun. From the egg a small maggot emerges and whoever eats dried figs must at times come across them. These larvæ, which emerge toward the end of September or October, render a voyage on a fig-laden ship very unpleasant, as they crawl about the ship before pupating.

Finally, we must not forget the biscuit "weevil," so familiar to us in Marryat's novels. And the first thing to notice about it is that it is not a weevil at all. It is in truth known as *Anobium paniceum*, and is closely allied to *A. striatum*, which makes the little round holes in worm-eaten furniture so cleverly imitated by second-hand furniture dealers. There is hardly anything the larva of this insect will not eat, from cayenne pepper to opium, from tablets of compressed meat to Arabic manuscripts. It is, however, to-day far less common than in the past through the invention of the biscuit-tin, a comparatively modern discovery, which has done much to interfere with its plans.

The Precious Stones Industry in the United States

Mining of precious stones in the United States has been a variable industry since its beginning. Most of the gem minerals have been sporadically mined or found during the course of mining for other minerals, and only a few varieties have been systematically mined for periods of years at a time. Among those minerals which have been most persistently produced, and in some quantity at different times, are sapphire, turquoise, tourmaline, spodumene and chrysoprase. A few other gems such as beryl, garnet, quartz, agate, amazon stone, rose quartz, and variscite, have been produced somewhat regularly, but generally in small quantity.

George F. Kunz,[1] summarizing the production and the localities of the different gem minerals in 1882, mentions the following:

Occasional diamonds had been found in several States. Sapphire was known to occur along Missouri River near Helena, Mont., and both ruby and sapphire at the Jenks corundum mine in Macon County, N. C. Topaz had been found in Maine and Colorado. Emerald and hiddenite had been discovered sixteen years before in Alexander County, N. C. Aquamarine and other beryl were obtained from several of the Eastern States. Garnets, called "Arizona ruby," were being collected each year by the Navajo Indians in some quantity. Tourmaline had been mined for many years at Mount Mica, near Paris, Me., and was known to occur at other localities and also in Connecticut. Quartz and rock crystal were obtained from numerous scattered localities, especially fine small crystals coming from Herkimer County, N. Y., and Hot Springs, Ark. Rose quartz was found at several places in New England. Gold quartz from several Western States was made into jewelry. Amethyst had been found in Maine, Pennsylvania, Virginia and Colorado. Agate was known to occur in many States, and the Wyoming and Montana moss agates were used in large quantities. Jasper and petrified wood were found in many States and used in small quantities. Peridot was gathered by the Navajo Indians of Arizona. Turquoise was known in New Mexico, Arizona and Nevada. The feldspar gems, labradorite, amazon stone, sunstone and moonstone were used in small quantities. The amazon stone came from the Pikes Peak region, Colorado. The Lake Superior gem stones, thomsonite and chlorastrolite, were collected for the tourist trade. Numerous lesser gems were known to occur in the United States, but were only sparingly used, such as phenacite, hyacinth, garnet, iolite, rutilated quartz, novaculite, rutile, prehnite, obsidian, diopside, chrysoprase, rhodonite, malachite, chiastolite, catlinite and others.

The following summary includes only a few of the principal features in the precious stones industry in the United States since 1882:

Diamond.—Only scattered finds were reported in various States, some in river and glacial gravels, and others loose in the soil, until 1906, when diamond was found associated with decomposed peridotite matrix in Arkansas. Since that time 2,000 to 3,000 stones have been found on the surface and by washing the earthy matrix. The value of the Arkansas deposits has yet to be demonstrated.

Sapphire.—A few sapphires were saved from the placer gold mining along Missouri River near Helena, Mont., until about 1890, when active mining for the sapphire was undertaken in connection with mining for gold. In 1891 and for several years following mining was continued successfully. In 1893 placer sapphire deposits were discovered along Rock Creek in Granite County. In 1894 more placer sapphire deposits were found along Dry Cottonwood Creek, in Deerlodge County, and near Yogo Gulch, in Fergus County. The Yogo sapphires are nearly all true sapphire blue and were soon traced to their original matrix, from which they have been mined almost continuously to the present. All of the other placer sapphire deposits produce only varicolored stones, including no pure blue gems. They are used principally for mechanical purposes, such as meter and watch bearings.

Ruby.—Occasional rubies were found in the corundum deposits of North Carolina and Georgia. The best find of ruby was made in 1893 in Cowee Valley of Macon County, N. C., in placer deposits. A few fine gems were found, and later the stones were traced to their original matrix, where prospecting has been tried at various times without definite results.

Topaz.—Topaz mining has never reached an important stage in the United States. Since 1882 the more important finds have been on Baldface Mountain, near North Chatham, N. H., in 1888; in San Diego County, Cal., about 1903, and in Mason County, Tex., in 1904. These deposits, as well as others in Maine, Colorado and Utah, are only intermittently worked. The majority of the topaz from the United States is colorless, but some fine blue and bluish-green crystals are found.

Emerald.—The principal emerald localities of the United States are in North Carolina, but a few inferior emeralds have been found in Maine and Connecticut. In North Carolina the emerald-hiddenite mine has already been referred to. After 1891 operations were limited to a little intermittent prospecting, the last of which was in 1907. In 1894 emerald was found on Crabtree Mountain in Mitchell County, N. C., and mining was conducted for a few years. This locality did not produce clear gem emeralds, but a quantity of stones were cut with the white, gray and black associated matrix, and sold under the name of emerald matrix. In the same year, 1894, a stray emerald of good color was found near the North Carolina-South Carolina State line, south of Shelby. This was a forerunner of the discovery of the emerald deposit on the Turner plantation, five miles southwest of Shelby, in Cleveland County, N. C., in 1909. This deposit was worked by the Emerald Company of America and yielded the best colored emeralds so far found in the United States. Work was stopped in 1913.

Aquamarine and other beryl gems.—Beryl gems have been obtained intermittently from many localities, prominent among which are Stoneham and other localities in Maine; Royalston, Mass.; Merryall, Conn.; Alexander, Mitchell, Yancey and Macon Counties, N. C.; Mount Antero, Chaffee County, Colo.; Riverside and San Diego Counties, Cal. The localities are scattered and mining and prospecting have been irregular.

Garnet.—The "Arizona ruby" or garnet from the Navajo Indian Reservation has supplied the gem trade with varying quantities of fine garnet to the present time. Mason branch in Macon County, N. C., yielding the rose-pink rhodonite garnet, was an important source of gem garnet from 1897 to 1901. The majority of other gem garnets have been obtained from numerous localities and chiefly during mining for other minerals. Noteworthy among these was the hyacinth or spessartite variety from Amelia, Va., and from San Diego County, Cal.

Tourmaline.—Tourmaline has been obtained intermittently, but not in large quantities from several localities in Maine and Connecticut. After 1900 the deposits of southern California became large producers and were actively worked for several years. Since 1911 only a few of these mines have been systematically worked, and the production has not been large. In connection with tourmaline mining in southern California lilac to rose-colored spodumene, called "kunzite" and "California iris," has been obtained in quantity and has taken an important place among American gems.

Chrysoprase.—Chrysoprase was first found near Riddle, Oreg., in 1884. In 1887 deposits were discovered in Tulare County, Cal. There was only a small annual production for a number of years, but between 1901 and 1911 the output was large.

Quartz.—Fine quartz crystals have been obtained from mines worked for tourmaline and other gem minerals in various parts of the country. One of the most important finds was of a lot of large, clear crystals on Mokelumna Hill, Calaveras County, Cal., in 1898. One of these crystals yielded a flawless sphere 5½ inches in diameter.

Amethyst.—Amethyst has been mined in some quantity in Georgia, North Carolina, and Virginia, and small outputs have come from numerous other deposits in these and other States.

Agate.—Agate has been obtained from most of the Western States, and in some years the production has been large. The moss agates of Montana and Wyoming continue to be of importance because of their beauty and of the quantity in which they are found.

Jasper.—The varieties of jasper suitable for ornamental purposes known in the United States have increased greatly. Among the promising varieties are bloodstone from the Death Valley region, California, and kinradite or spherulitic quartz and associated jaspers of the San Francisco region.

Peridot.—Peridot has been obtained sporadically and occasionally in some quantities from both the Navajo and the Apache Indian Reservations in Arizona. It is collected chiefly by the Indians.

Turquoise.—Up to 1888 the output of turquoise mining was small, but regular mining was then begun, first at Cerrillos, N. Mex., and later in the Burro Mountains, N. Mex., and in Saguache County, Colo. The production rose to $175,000 in 1892. Arizona, California and Nevada have since entered the list of turquoise-producing States, and have contributed large quantities at different times. The climax in the production of turquoise came in 1909, when more than 17 tons of turquoise and matrix was mined. The value of this rough product was estimated at about $179,000.

Feldspar Gems.—Amazon stone is the principal feldspar gem mined in the United States. The Pikes Peak region of Colorado has continued to yield a quantity of this stone nearly every year. Amelia, Va., has been another source of supply of much good grade of amazon stone.

Other Semiprecious Stones.—The production of numerous other gems has been quite variable. The thomsonite and chlorastrolite beach pebbles of Isle Royale, Lake Superior, have been gathered more or less regularly by tourists each year. Other varieties of beach pebbles are collected for ornamental purposes along the Pacific coast. Of the numerous other minerals sometimes used for gems or ornaments mentioned as known in 1882, rhodonite, malachite, rose quartz and catlinite have been used in some quantity.

New Gem Minerals.—Among new gem minerals may be mentioned californite (massive compact vesuvianite) and benitoite, both found in California. Californite has been found in several counties and a quantity has been sold at different times. Benitoite is a barium titanosilicate. It is a new mineral discovered in San Benito County in 1906. Only one deposit, now exhausted, has been found. Benitoite is a blue mineral resembling sapphire in color but much softer. It has a high refractive index and strong dichroism.

The value of the total production for the years 1883 to 1914 amounts to $7,799,971. Kunz has made an estimate of the total production for the three years preceding 1882 as follows: 1880, $100,000; 1881, $110,000; 1882, $150,000. This makes a grand total of the production of gems and precious stones in the United States from 1880 to 1914 of $8,159,971.—*Mineral Resources of the United States, published by the U. S. Geological Survey.*

[1]Precious Stones: U. S. Geol. Survey Mineral Resources U. S., 1882, 1883.

Loss of Weight by Platinum Crucibles.

According to investigations made by Messrs. Burgess and Sales of the Bureau of Standards, the loss of weight due to heating per 100 centimeters of practically iron-free crucible surface at 1260 deg. Cent., ranges from 0.71 milligramme to 2.69 milligrammes per hour, the lesser losses being for crucibles containing rhodium and the greater losses being associated with iridium.

NEW BOOKS, ETC.

THE BRITISH JOURNAL PHOTOGRAPHIC ALMANAC. By George E. Brown, F. I. C. London: Henry Greenwood & Co., Ltd., 1916. 8vo.; 982 pp.; illustrated.

Although two thirds of this volume from over the water is taken up with advertising, the remainder contains that wealth of information which earlier issues have led us to expect, and both amateur and professional workers may turn to it with confidence. One change in its make-up is significant. British manufacturers of photographic supplies have been handicapped, since the outbreak of the war, by lack of raw materials, poor transport facilities, and a shortage of labor; hence in place of the usual review of the year's new photographic appliances, we are given a survey of British resources in the home production of materials. It is gratifying to learn that substantial progress has been made in many directions toward independence of German supplies.

RELATIVITY AND THE ELECTRON THEORY. By E. Cunningham, M. A. New York: Longmans, Green & Co., 1915. 8vo.; 96 pp.; with diagrams. Price, $1.10 net.

The hypothesis of relativity—that it is impossible by physical experiments to determine the absolute velocity of a body through space—is set forth in as simple a manner as possible in Prof. Cunningham's monograph. The relation of this principle to the accepted electron theory is then clearly developed. Mathematics have been so far excluded as to make the information of the volume easily accessible to the experimental physicist, and also within certain limitations, to the intelligent general reader.

PRINCIPLES AND PRACTICE OF COST ACCOUNTING. By Frederick H. Baugh. Baltimore: F. H. Baugh, 1915. 8vo.; 194 pp. Price, $3 net.

Mr. Baugh's work is a comprehensive survey of the basic principles of cost accounting, with their general application to the most common types of manufacturing. In order to restrict the subject to a single volume, unburdened by a mass of detail, only portions of which would be necessary to any one enterprise, factory management is regarded as a subject outside of cost accounting proper, and the multitudinous forms, such as payrolls, production orders and requisitions have been omitted, since they may easily be formulated to suit special requirements. The author handles his material in a logical and understandable way, and covers specific job, departmental, and process costs in away suited to the needs of accountants, manufacturers, and students in general.

THE NEW YORK CHARITIES DIRECTORY. A Reference Book of Social Service in or Available for Greater New York. By Lina D. Miller. New York: Charity Organization Society, 1916. 12mo.; 434 pp.

The twenty-fifth edition of The New York Charities Directory adopts a new form and a new and clearer typography. The work has long outgrown its title, and now includes all forms of social service in the widest application of that term. The agencies engaged in social, civic, religious and educational work in New York city, as well as many national organizations, are listed, and the alphabetical arrangement of the various sections of the volume is augmented by a very full name index.

WHY WE PUNCTUATE. Or Reason Versus Rule in the Use of Marks. By William Livingston Klein. Minneapolis: The Lancet Publishing Company, 1916. 8vo.; 224 pp. Price, $1.25 net.

This excellent work, entirely rewritten for its second edition, attacks the problems of punctuation in an original and most efficient manner. Correct punctuation pre-supposes correct interpretation of the subtle relationships existing between word-groups, and the author leads the student by easy steps from the simple to the complex. Instead of dealing separately with the various marks beginning, as is usual, with the difficult comma, this treatise exhibits groups of inter-related marks in a single illustrative sentence, and argues from the sense relations of the word-groups. The mode of treatment and the clarity of the text make the work worthy of commendation.

OLD MARBLEHEAD SEA CAPTAINS. And the Ships in Which They Sailed. Compiled and published for the benefit of the Marblehead Historical Society. By Benjamin J. Lindsey, Treasurer. 8vo.; 137 pp.; illustrated. Price, $2.50; by mail $2.65 postpaid.

These records make a most interesting compilation, and will delight those to whom the adventurous pioneers of our early merchant service represent a chapter from the romance of our history. Particularly will the descendants of this sturdy stock enjoy the brief personal sketches, often accompanied by portraits from age-mellowed ambrotypes and original paintings. The ships, too, are shown, now gliding under full canvas, now driving under bare poles through mountainous seas. Several plates in color give the private signals of the old Marblehead clippers.

PAINLESS CHILDBIRTH. Eutocia and Nitrous Oxid-Oxygen Analgesia. By Dr. Carl Henry Davis. Chicago: Forbes & Co., 1916. 12mo.; 134 pp. Price, $1 net.

A timely work, the first by an obstetrician to discuss the various methods used, is this illuminating treatise on painless childbirth. The subject, which has but recently received wide publicity under the alluring name of "twilight sleep," is really of ancient origin; the theory was successfully put into practice by Simpson at the birth of the late King Edward. Dr. Davis compares the chemistry, pharmacology, and toxicology of the different analgesics, and considers their advantages and disadvantages in what impresses the reader as an unbiased spirit. Obstetrical authorities and mortauty records are liberally quoted, and maternity is shown to be more dangerous to-day than when anesthetics and antiseptics were unknown. Certain usages prevalent among physicians are condemned, and a strong argument for nitrous oxid-oxygen analgesia is put forward. This method achieved its successes in Europe in the early '80s, and these successes have been recently duplicated in American hospitals.

IGNITION, TIMING AND VALVE SETTING. Including Electric Self-Starting and Lighting Systems. By Thomas H. Russell, A. M., M. E. With numerous revisions and extensions by John B. Rathbun. Chicago: Charles C. Thompson Company, 1916. 12mo.; 240 pp.; illustrated. Price, cloth, $1; leather, $1.50.

The subjects here dealt with are still, despite the marked constructional improvements of the last few years, of great importance to owners and operators of automobiles, motor boats, and stationary engines. By making these subjects the material of a separate, complete volume, there is a certain gain in emphasis and thoroughness. The treatise definitely sets forth the vital principles of ignition systems, so that any particular apparatus may be handled with ease and skill. The high tension magneto and the various forms of dual ignition circuits receive special attention, and the section on valve timing includes the exact timing figures issued by leading manufacturers for their various car models, so that even the tyro may get good results without long experimenting.

LEKTRIK LIGHTING CONNECTIONS. With Introductory and Explanatory Notes by W. Perren Maycock, M. I. M. E. London: A. P. Lundberg & Sons, 1916. 146 pp.; illustrated. Price, sixpence net.

"Lektrik Lighting Connections" appears in a fourth edition as a convenient vest-pocket guide dealing helpfully with the important and somewhat neglected subject of switch control.

THE CORROSION OF IRON. A Summary of Causes and Preventive Measures. By L. C. Wilson. New York: The Engineering Magazine Company, 1915. 12mo.; 178 pp. Price, $2.

These papers bring together in condensed form the most important studies and the leading facts connected with the corrosion of iron and with its adequate protection. This annoying and costly process of decay has recently been investigated scientifically, and many facts of its true character and its amenability to treatment have been brought to light. We now know more of the defects and benefits of oxide coating, paint coating, and metal coating; the author has carefully weighed these studies, and has estimated their comparative results and efficiencies, in the papers here reprinted from *The Engineering Magazine* and published under the auspices of the Works Management Library.

SMOKE ABATEMENT. And Electrification of Railway Terminals in Chicago. Report of the Chicago Association of Commerce, Committee of Investigation on Smoke Abatement and Electrification of Railway Terminals. W. F. M. Goss, Chief Engineer. Chicago: Rand, McNally & Co., 1915. 4to.; 1177 pp.; illustrated. Price, $6.

Smoke plunges the most beautiful city into mourning, and Cleveland estimates its actual loss from this source at $12 per capita every year, divided among extra maintenance cost, higher depreciation, and direct loss of value. Enormous damage is worked upon vegetation. The smoke pall may reduce solar energy by 40 per cent, and its deposit upon leaves further reduces this energy. Its free acids lower the vitality of plants and diminish their digestible qualities. Above all, whatever may be the doubt as to the action of smoke on healthy lung tissue, it is certainly a grim handmaid to tuberculosis and the respiratory diseases. The mammoth Report of the Chicago Association reviews all these arrangements, cites authorities, and urges the necessity of electrifying railroad terminals as a means of combating the menace. It enters exhaustively into questions of feasibility and cost and studies the anticipated results. While its direct concern is with the city of Chicago, its investigations and suggestions are manifestly applicable to all large cities. It brings together the knowledge of many years and many men, and is well worthy the attention of all students of the vital question of smoke abatement.

THE CONSTRUCTION OF THE PANAMA CANAL. By William L. Sibert, Brigadier General, U. S. A., and John F. Stevens, formerly Chief Engineer and Member of the Isthmian Canal Commission. New York: D. Appleton & Co., 1915. 8vo.; 338 pp.; illustrated. Price, $2 net.

The Panama Canal is a wonderful dream come true. At every step of the planning, no less than at every bite of the giant dredges, a thousand obstacles and exigencies threatened to spoil this dream. Mr. Stevens gives us a good history of the preparatory period, with its preliminary discussions, its reconstruction of the Panama Railroad, the development of working plans, and the housing, feeding, assemblage and management of the huge force. Brigadier-General Sibert follows with the narrative of actual construction. He tells us of lock design, of excavation and concrete work, of Gatun dam and lake, of the municipal and sanitary engineering involved, of shops and terminal facilities, and of the mode of operation. His final chapter, which rounds out a work of distinct merit, deals with the statistics of material and costs.

BETWEEN THE LINES. By Boyd Cable. New York: E. P. Dutton & Co., 1915. 8vo.; 258 pp. Price, $1.35 net.

"Between the Lines" was written at the front, with the roar of German guns in the writer's ears. Its style is vivid, with a touch of the sensational, and quite serves the purpose of bringing home to us the actual crash of battle and the after sufferings this entails. The enthusiastic reception by the English of the "Hymn of Hate" is a characteristic touch. The narrative enables us to read "between the lines" of the dry official despatches.

IRRIGATION IN THE UNITED STATES. A Discussion of Its Legal, Economic and Financial Aspects. By Ray Palmer Teele, M.A. New York: D. Appleton & Co., 1915. 8vo.; 253 pp.; with chart. Price, $1.50 net.

Upon the subject of irrigation there is more popular misinformation, the author declares, than upon any other subject he knows of, and his sixteen years' experience as irrigation economist with the Department of Agriculture should give him the right to express an opinion. His book is particularly addressed to persons contemplating settlement in an arid section and to investors in irrigation securities. He is a thorough believer in irrigation and in the present and future of the West, but he realizes that exaggerations as to crops and profits must ultimately injure, not only investors, but the enterprise itself. The papers bring together in condensed and readable form the drier information of many scattered bulletins and monographs, and deal with climate, water supply, crops, water rights, laws, and the organization, financing and control of irrigation enterprises.

PROFIT AND PLEASURE IN GOAT-KEEPING. By Fred C. Lounsbury. Plainfield, N. J. Published by the Author, 1915. 43 pp.; illustrated. Price, 35 cents.

This brochure contains much reliable information on the various breeds of milch goat, with complete instructions for their care and management. It is conservatively written, and no sensational claims are put forward, but the author establishes the fact that not only is there for the animal lover a pleasurable occupation in goat-keeping, but there may be a satisfying margin of profit as well.

THE SPELL OF BELGIUM. By Isabel Anderson. Boston: The Page Company, 1915. 8vo.; 442 pp.; illustrated. Price, $2.50 net.

This is a most opportune volume of the Spell Series. Its earlier chapters lead us through ancient gateways into the historic splendors of the past. The material and artistic achievements of this staunch little nation are brought sharply upon the screen; we are introduced to her modern masters of art, music, and literature. Old legends charm us, old deeds stir us; but the glory of Belgium does not rest upon a remote past, and the final pages of this work sketch the preliminaries of the great war, and the ruthless spoliation of Belgium in the face of an heroic resistance. In this section we are given some good pictures of the Belgian army, the refugees, and Ypres after bombardment.

INVENTORS AND MONEY-MAKERS. By F. W. Taussig, Ph.D., LL.B., Litt.D. New York: The Macmillan Company, 1915. 12mo.; 135 pp. Price, $1.

Prof. Taussig here transcribes certain lectures delivered at Brown University, and dealing with those relations between economics and psychology which have to do with the phenomena of instinct. He discusses the instinct of contrivance; the situation existing between employer and employee, with available remedies for the prevailing friction; the psychology of money-making; and altruism, the "instinct of devotion."

THE A-B-C OF NATIONAL DEFENSE. By J. W. Muller. New York: E. P. Dutton & Co., 1915. 12mo.; 215 pp. Price, $1 net.

The author of "The Invasion of America" emphasizes the necessity for a cohesive or balanced fleet; the battleship's dependence upon the swift cruiser is convincingly argued, and the menace constituted by our failure to provide these scouts is clearly disclosed. At the door of Congress Mr. Muller lays the blame for high naval expenditure with low efficiency results, as he does, too, the odium of the fact that our navy is "a creature without a head"—the only navy in the world without a general staff or its equivalent. The work goes on to deal with the army in the same concise, forceful, and informative way.

MAKING THE MOVIES. By Ernest A. Dench. New York: The Macmillan Company, 1915. 12mo.; 177 pp.; illustrated. Price, $1.25.

THE ART OF THE MOVING PICTURE. By Vachel Lindsay. New York: The Macmillan Company, 1915. 8vo.; 289 pp.; Price, $1.25.

"Making the Movies" is a "close-up," to use a phrase of the industry. It brings us face to face with the performers, and shows us just how they work, how effects are produced, and how very real perils often confront them. We acquire an intimate acquaintance with the motion picture studio, and come to appreciate the difficulties of handling masses of humanity in a realistic manner. "The Art of the Moving Picture" seeks to establish a basis for photoplay criticism, incidentally treating all photoplays as pictures either of action, such as "The Spoilers," of intimacy, such as "Enoch Arden," or of splendor, which may include the fairy tale, the historic film, and the story which relies for its main effects upon the movement of crowds.

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